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NORTHWEST OKLAHOMA WATER SUPPLY STUDY

SPECIAL REPORT
AUGUST 1991

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

GREAT PLAINS REGION — BILLINGS, MONTANA

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Mission: As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.

SPECIAL REPORT
ON
NORTHWEST OKLAHOMA
WATER SUPPLY STUDY
OKLAHOMA

U.S. Department of the Interior
Bureau of Reclamation
Great Plains Region
Billings, Montana

DISCLAIMER

Publication of the study results presented herein should not be construed as representing either the approval or disapproval of the Secretary of the Interior.

The purpose of this special report is to document the results of the investigation and present the study findings to interested publics and those local, State, and Federal agencies participating in the study.

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    The Adams Cattle Company

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TRANSPOSED TO

END OF VOLUME

INTRODUCTION

BACKGROUND

In October 1984, the Bureau of Reclamation (Reclamation) initiated a comprehensive planning investigation of the short- and long-term municipal and industrial water supply needs of the northwest Oklahoma study area. The initial study objectives were to analyze the capability of existing or potential sources of water to meet identified needs, formulate alternative plans to develop and convey available water resources, determine the environmental consequences of potential plan development, and recommend a course of action. All potential sources of water were to be considered, including ground water; surface water from existing or potential sources, both within and outside the study area; and available water supplies of poor quality that might be made usable by special treatment or desalination. Other needs including flood control, recreation, and environmental enhancement were also to be considered.

New irrigation development was not to be a project purpose. However, because irrigation is by far the greatest use of water in the study area, that use would be considered in assessing the availability of ground-water resources for meeting other needs.

As the study progressed and data were gathered and evaluated, it became apparent that the investigative procedures and requirements of Reclamation's conventional planning process would result in the expenditures of funds (staff time) that would exceed authorized funding levels for the study. Therefore, a change in study scope was deemed appropriate.

A meeting was held on September 15, 1988, with the Oklahoma Water Resources Board and the Oklahoma Economic Development Association. It was concluded by those attending the meeting that the study thrust should change to a "Special" category. The principal objective of the investigation would be to provide a product that would focus on meeting only the needs and expectations of the local officials; e.g., a service plan that would develop surface water supplies for municipal and industrial use and provide or improve flat water recreation opportunities for the study area.

PURPOSE OF THIS REPORT

This special report documents Reclamation's investigation to identify the water resource development needs in the study area and provide a preliminary plan, including estimated costs, to meet those needs. The level of detail presented in the report is considered to be subfeasibility.

This report is not a document that would be used by Reclamation to support Federal authorization of the plan, but one that is specifically developed to meet the project sponsor's needs in identifying the most promising alternative plan(s) of supplying the study area with municipal and industrial water from surface water resources and improving flat water recreation.

STUDY AUTHORITY

The investigation was conducted under the general authority provided by the Federal Reclamation Act of 1902. Funding for the study was provided through Federal appropriations initiated in fiscal year 1985.

The Governors of Oklahoma and Kansas, Oklahoma Water Resources Board (OWRB), Oklahoma Economic Development Association (OEDA), and the Kansas Water Office have expressed their support of the study.

STUDY AREA DESCRIPTION

The study area is composed of the eight northwest counties of Oklahoma. The counties are: Beaver, Cimarron, Dewey, Ellis, Harper, Texas, Woods, and Woodward. The eight counties have a land area of 11,501 square miles with an average population density of 6.1 persons per square mile. Population density ranges from 2.0 persons per square mile in Cimarron County to 17.0 persons per square mile in Woodward County. However, the study area is not limited to Oklahoma and includes the bordering water-short counties of southwest Kansas.

The study area is bounded on the north by the States of Colorado and Kansas; and on the west and south by New Mexico and Texas respectively.

The General Map (frontispiece) shows the location of the study area.

STUDY ACCOMPLISHMENTS

1. Planning Plan of Study, dated August 1984.

2. Report on Northwest Oklahoma Water Supply Study, Oklahoma, dated November 1986, at the request of Congress, pursuant to the Energy and Water Development Appropriations Act 1987 (Public Law 99-500, dated October 1986).

3. Preliminary Findings Memorandum, dated May 29, 1987.

4. Northwest Oklahoma Water Supply Study Report prepared by the Oklahoma Economic Development Association under contract with Reclamation. The report covers the areas of (1) land use; (2) population; (3) economy; (4) municipal water systems; (5) industrial/manufacturing water use; (6) irrigation; (7) steam and powerplants; (8) mining and extractive industries; (9) livestock; (10) other water uses; and (11) a summary, along with background data of the area.

5. Hydrologic study contracted with Reclamation by Boyle Engineering Corporation, Lakewood, Colorado, consisting of:

Phase I - Rainfall/Runoff Analysis, dated October 1987;

Phase II - Water Supply Availability, dated November 1987; and

Phase III - Salinity Investigation, dated February 1988.

6. Technical Memorandum, Subappraisal Investigation, Kiowa and Amber Dam and Reservoir Sites, Kansas, dated June 1988.

7. Technical evaluation of diverting water from the Cold Springs site through a canal to Optima Reservoir. (Memorandum report, undated)

8. Supporting data and findings prepared by the individual team members participating in the investigation.

STUDY COORDINATION AND REVIEW

Coordination for the study was provided by Reclamation personnel from the Oklahoma - Texas Projects Office, Oklahoma City, and the Office of the Assistant Commissioner - Resources Management, Denver, Colorado.

Other Federal and State agencies that participated in the study are:

1. U.S. Fish and Wildlife Service, Ecological Services, Tulsa, Oklahoma, and the Kansas State Office, Manhattan, Kansas.

2. Department of the Army, Corps of Engineers, District Office, Tulsa, Oklahoma.

3. Oklahoma Water Resources Board, Oklahoma City, Oklahoma.

4. Oklahoma Economic Development Association, Beaver, Oklahoma.

5. Oklahoma Department of Wildlife Conservation, Oklahoma City, Oklahoma.

6. Kansas Department of Wildlife and Parks, Operations Office, Pratt, Kansas.

7. Kansas Water Office, Topeka, Kansas.

The draft of the Special Report for the Northwest Oklahoma Water Supply was distributed to study participants and interested publics for their review and comment. The review period occurred from November 1990 to February 1991 and the letters of comment received as a result of that review are contained in attachment F.

Reclamation considered all the comments during the preparation of the final report; however, some comments could not be addressed at this level of study. Should more detailed studies be initiated at a later date, those comments not previously accommodated would be given further consideration at that time.

SETTING

CLIMATE

The climate of the study area ranges from semi-arid in the western panhandle to subhumid in the eastern counties. Summers are long and occasionally hot with temperatures of 90 °F (degrees Fahrenheit) or higher occurring, on an average, about 85 days per year. The average length of the growing season is about 168 days in the panhandle area.

The winters are shorter and less severe than those of the more northern Plains States. Extended periods of extreme cold are infrequent. Temperatures of 32 °F or less occur, on an average, 125 to 140 days in the panhandle. The average maximum depth that frost penetrates the soil is about 10 inches in the northwest counties, but on occasion it can reach a depth of 30 inches during extreme cold periods.

Average annual precipitation varies from 16 inches in the panhandle to about 25 inches in eastern Woods County, with most of it occurring in the spring. Snowfall averages about 18 to 20 inches per year with water content of the snowfall included in the total annual precipitation figure.

Average annual lake evaporation ranges from 56 inches to about 88 inches in the study area. High winds, hot temperatures, and low relative humidity levels all contribute to the high evaporation rates. Prevailing winds are southerly although northerly winds predominate during the winter months. Average annual wind speeds vary from 9 miles per hour (mph) to about 14 mph, east to west in the study area.

MAJOR DRAINAGE BASINS

The eight-county study area is traversed by two major streams: the Cimarron River and the North Canadian (Beaver) River. Both rivers are tributaries of the Arkansas-White-Red River Basin. A small portion of Dewey County in the southeast corner of the study area is drained by the Canadian River. Figure 1 shows the rivers and related tributaries that drain the study area.

The principal river basin running through the study area is the North Canadian (Beaver) River. The stream flows west to east through Cimarron, Texas, and Beaver Counties and then turns to a southeast direction flowing through Harper, Woodward, and the northeast corner of Dewey County. Major tributaries to the North Canadian River are Palo Duro, Coldwater, Kiowa, and Wolf Creeks.

The topography of the North Canadian River in the study area consists of high plains and rolling prairies, and the land is used primarily for farming and ranching. The sandy river channel has a low base flow, and long periods of no flow are common. Estimates of average annual runoff range from 0.2 inches in the western panhandle area to up to 2.0 inches in the eastern portion of the study area (Boyle, 1987a).

The North Canadian River water quality is poor in the study area due to elevated levels of nitrogen and phosphorus in the upper reaches and increased mineralization by sulfates and chlorides downstream, preventing use (untreated) for most municipal and domestic purposes.

The Cimarron River originates in northeastern New Mexico and enters Cimarron County of the Oklahoma Panhandle from the west. It flows east for a short distance then turns north entering Colorado and then east again to enter Kansas. The river returns to Oklahoma in Harper County and flows southeast leaving the study area in Woods County. The Cimarron River runs through a salt bed near a point where Harper, Woods, and Woodward County lines intersect. Water quality is significantly diminished downstream from this area.

SURFACE WATER DEVELOPMENT

Streamflow, rainfall, and reservoir yield rates increase from west to east and from north to south in the study area. At present, there are only a few small- to modest-sized reservoirs that serve the needs of water supply, recreation, and flood control. The two largest reservoirs are Canton Reservoir, located in portions of Dewey and Blaine Counties, and Fort Supply Lake, located in Woodward County. A third reservoir, Optima Reservoir, is located in Texas County of the panhandle; but to date, the reservoir has experienced low inflow volumes and has not yet become a viable surface water development. Table 1 provides pertinent data on the existing reservoirs in the area.

GROUND-WATER RESOURCES

A brief description of the major aquifers in the study area follows.

Ogallala Aquifer (also High Plains Aquifer)

This aquifer underlies all of the counties in the Oklahoma Panhandle and it extends east a short distance into Harper, Ellis, Woodward, and Dewey Counties. This aquifer is the principal source of agricultural and domestic water use in

Table 1.—Existing reservoirs in northwest Oklahoma study area

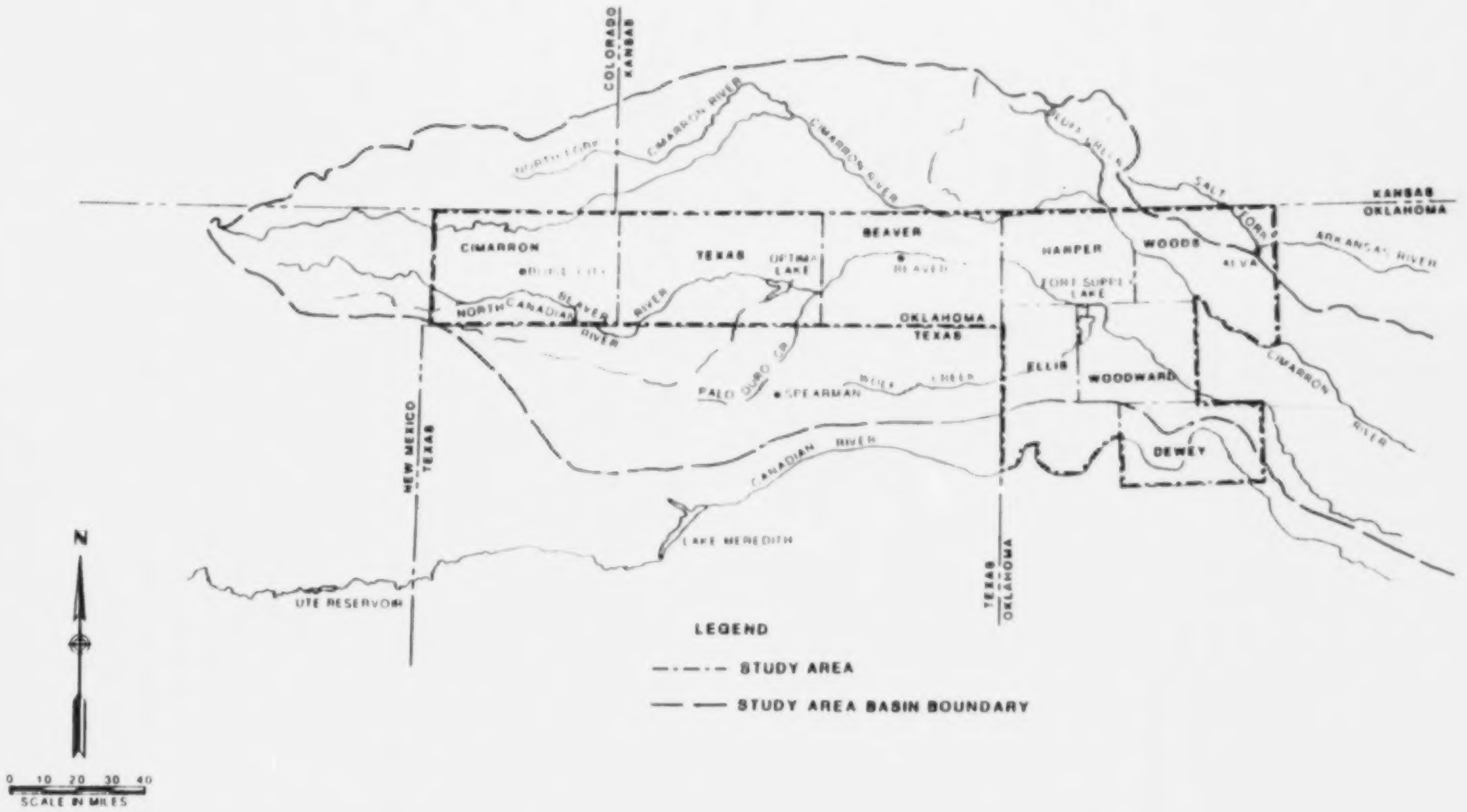
Item	Canton Lake[1]	Ft. Supply Lake	Optima Lake[2]
Drainage area, mi^2	12,843	1,735	5,029
Noncontributing, mi^2	(4,899)	(241)	(2,688)
Flood control storage, acre-ft	267,800	86,800	71,800
Water supply storage, acre-ft	107,000	400	76,200
Water supply yield, acre-ft/yr	13,440	220	5,400
Date completed	July 1948	May 1942	Sept. 1978
Amount appropriated, acre-ft	0	7,051	0

Source: OWRB, May 1980

[1] 80,000 acre-feet of water for Oklahoma City is stored in Canton Lake for release to Lake Overholser.

[2] Reservoir has never filled and no water supply is available as of September 1990.

Figure 1. River systems-Northwest Oklahoma Water Supply Study Area


COLORADO
KANSAS
NORTH FORK
CIMARRON RIVER
CIMARRON RIVER
BLUFF CREEK
SALT FORK
KANSAS
OKLAHOMA
ARKANSAS RIVER
CIMARRON
BOISE CITY
TEXAS
OPTIMA LAKE
BEAVER
BEAVER
HARPER
FORT SUPPLY LAKE
WOODS
ALVA
NORTH CANADIAN
BEAVER RIVER
RIVER
OKLAHOMA
TEXAS
PALO DURO CR
SPEARMAN
WOLF CREEK
ELLIS
WOODWARD
CIMARRON RIVER
DEWEY
CANADIAN RIVER
NEW MEXICO
TEXAS
LAKE MEREDITH
UTE RESERVOIR
TEXAS
OKLAHOMA
N
0 10 20 30 40
SCALE IN MILES
LEGEND
STUDY AREA
STUDY AREA BASIN BOUNDARY

these counties. Most wells in the panhandle yield about 500 to 1,000 gallons per minute (gal/min). In the eastern counties where this aquifer thins out, the yields are about 200 gal/min. Well depths normally range from 100 to 500 feet. The quality of water in this aquifer is considered to be good.

Since the advent of irrigation in the 1940's, this aquifer has experienced a gradual decline in the volume of water remaining in storage. By 1980, ground-water withdrawals by wells for combined irrigation, municipal, and industrial uses were approximately 373 million gallons per day (mgd). As a result, regional water levels were lowered as much as 50 to 150 feet in parts of Texas County and 10 to 50 feet in parts of Cimarron County, Oklahoma. Similar trends in water-level declines have accompanied the growth in irrigation pumping in areas of southwestern Kansas and the northern Texas Panhandle.

However, since 1980 some regions of this aquifer have experienced a slight rise in water levels which suggest that some portions of the aquifer may now be stabilizing. This trend is ascribed in part to the recent reductions in agricultural demands for irrigation water.

On a regional basis, the Ogallala aquifer is not considered a reliable target for future development of sustained, large volume water supplies. Locally, however, the Ogallala aquifer exhibits areas of relatively stable water levels, and some areas of water-level recovery. Such areas of stable ground-water levels could be considered for development of interim ground-water supplies, recognizing that gound-water levels may resume their declining trend should agricultural demands for water increase. (Boyle, 1987b)

Rush Springs Sandstone Aquifer

This aquifer extends under parts of Beaver, Harper, Woods, Woodward, Ellis, and Dewey Counties. Potential recharge areas include exposed outcrops of the formation and overlying outcrops of gypsum and other rocks of the Cloud Chief Formation. Thickness ranges from less than 200 feet at the southern end to about 300 feet at its northern extent. Wells yield as much as 1,000 gal/min but average about 400 gal/min. Depth to water below the land surface is generally less than 150 feet.

Development of the Rush Springs Sandstone Aquifer for municipal and industrial water use has been limited in the study area. However, areas further to the south have seen extensive development of this aquifer for agricultural supplies.

The quality of the water in the aquifer is generally very hard, and in some areas, contains high concentrations of chlorides and sulfates.

Alluvial and Terrace Deposits

These deposits consist of unconsolidated clays, silts, sands, and gravels that were deposited by rivers and streams in irregular patterns. Alluvial deposits are generally found on and adjacent to an active river channel and are in direct hydrologic contact with the river. Therefore, reliability of alluvial water supplies is directly related to the reliability of suface-water flows.

Terrace deposits are generally older deposits left by rivers in their former courses, and are topographically higher than alluvial deposits. Recharge to terrace deposits occurs as direct infiltration of rainfall and excess applied irrigation water.

Total thickness of the deposits is variable, but averages about 70 feet. Well yields commonly average 100 to 300 gal/min; but yields can be as high as 1,000 gal/min. Development of ground water from alluvial and terrace deposits has been limited largely to irrigation supplies.

Water quality of the alluvial and terrace deposit aquifers will vary depending on the quality of the source stream water, the extent of irrigation practices in the area, and materials comprising the aquifer.

There may be some opportunity for additional development of ground water from alluvial and terrace aquifers through the conjunctive use of surface-water and ground-water reserves.

WATER QUALITY[1]

Surface Water

Mineralization of surface water appears to be the most serious known water quality problem.

The Oklahoma Water Resources Board (OWRB, 1980) states that Cimarron River water is very hard with moderate to high turbidity, pH in excess of standards, and some toxic metals problems. The Oklahoma State Department of Health (1982) reports that the Cimarron has high levels of cadmium, chromium, and lead just after entry to Oklahoma and continues at high levels as it flows through Oklahoma. When the river reenters the State from Kansas near Mocane, Oklahoma, the mean total dissolved solids (TDS) is slightly lower, but the water type has changed to sodium-chloride. In the next 90 miles, the mean TDS value rises to 35,000 milligrams per liter (mg/L) with a mean chloride content of 13,000 mg/L (Boyle, 1988).

The Beaver River near Guymon, Oklahoma, is a mixed carbonate/ bicarbonate type water with a low mean TDS of 330 mg/L. Highly saline Permian "red beds" are exposed near Beaver, Oklahoma. The river at Beaver has a mean TDS level of 2,100 mg/L of which more than 700 mg/L is chloride. Below Seiling, Oklahoma, the mean TDS value drops to 1,200 mg/L due to dilution and mixing (Boyle, 1988).

The OWRB (1980) states that the Salt Fork of the Arkansas River is highly mineralized and chemically unsuited for most beneficial uses. The Salt Fork of the Arkansas River and its tributaries above the Great Salt Plains have mean TDS values below 1,700 mg/L and are calcium-sulfate type waters. Near Ingersol, Oklahoma, mean TDS is 1,500 mg/L. Near Jet, 18 miles downstream from the station near Ingersol, the mean TDS quadruples to 6,000 mg/L, and the water becomes a sodium-chloride type water.

Ground Water

Water from the Ogallala aquifer is generally of good quality and, except for hardness, is suitable for most uses. However, in some areas the concentrations of chlorides, sulfates, and fluorides are high enough to make the water unsuitable for domestic use without proper treatment. The median TDS concentration of the aquifer water, reported by the U.S. Geological Survey (USGS) (1988), was 364 mg/L, with about 10 percent of the samples exceeding 1,000 mg/L. About 5 percent of the chloride and sulfate concentrations were larger than 250 mg/L. The median fluoride concentration was

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[1] Water quality terms frequently used throughout this report are defined in attachment A.

1.4 mg/L, and about 25 percent of the concentration exceeded 2.0 mg/L. Water withdrawn from the Rush Springs aquifer is a calcium-magnesium-chloride-sulfate type and is usually very hard. Chloride and sulfate concentrations have exceeded drinking water standards in some areas. The median TDS concentration was 408 mg/L with about 25 percent of the concentrations greater than 1,000 mg/L. Fewer than 5 percent of the chloride concentrations and about 30 percent of the sulfate concentrations were greater than 250 mg/L.

The quality of water in alluvial-terrace deposits usually reflects the quality found in the river associated with the deposits. High pumping rates in wells near the river may induce river water to be drawn into the well. Terrace deposits generally have better quality than alluvial deposits.

Saline Water

Natural pollution of ground and surface water occurs to some extent throughout the study area. Mineralization caused by leaching is the most common type of natural pollution. Precipitation percolating through salt-laden soils or the movement of ground water can take some minerals into solution and carry them into an aquifer. Minerals in ground water near the land surface can be concentrated by evaporation and transpiration at the land surface. Highly mineralized ground water can return to the surface as springs and seeps and contaminate surface water. Surface water can also become highly mineralized when flows encounter salt-laden formations.

The source of most mineralized water is from rock formations of Permian age which underlie the study area. The Permian rocks are composed of roughly 65 percent evaporites and 35 percent red beds (Reclamation, 1989). The formations consist of red and gray gypsiferous shale, siltstone, sandstone, gypsum, anhydride, dolomite, and sometimes halite (EPA, 1973). The rock formations are exposed in the eastern portion of the study area (see figure 2). The generalized geologic structure of the study area is shown in figure 3.

Salt water occurs at depths of less than 100 feet to more than 1,000 feet (EPA, 1973). The leaching of salt bearing formations near the surface and the regional circulation of ground water result in saline springs and seeps that contaminate the surface waters within the study area. Although flows from these springs are small, the TDS concentrations can be quite high. Alluvium deposits near these springs are saturated with high chloride-high sulfate waters and the evaporation of these waters from the surface cause the formation of salt crusts during dry weather.

TDS and other constituent concentrations in stream and small surface water bodies can be highly variable. High concentrations which occur during low flows are often diluted by relatively clean flood waters during high flows. During low flow periods, mineralized base flows will contribute a large fraction of the total stream flow. Base flow is that part of stream discharge derived from ground water seeping into the stream.

Boyle Engineering (1988) makes the following statement concerning how high flows can lower salt concentrations in surface water.

> Flood flows arrive at the stream through relatively fast overland flow processes. They have less time and opportunity to dissolve salts and deliver them to the stream. The result is dilution of the base flow with better quality water during periods of high flows.

Oil field brines which add to the salinity in surface water have been documented to be found in terraces along the Cimarron River in Oklahoma from the Kansas border to Logan County (Atkinson et al., 1986). Irrigation return flows also contribute to the salt loads in area streams. The amount of salt that is contributed by irrigation return flows is unknown. Along with salts, return flows contain pesticides and nutrients from fertilizers.

LAND USE

The study area lies in the region of Oklahoma characterized as having the most extensive agricultural activities in the State. Agricultural activities include feed and grain crops and cattle-feeding operations. Most of the irrigated crop lands rely on local ground-water resources for water. Table 2 illustrates the total land area of the study area distributed by county. Table 3 shows the agricultural land uses in the eight county area. Agricultural and range lands account for more than 90 percent of the total land areas.

Historical Setting

In 1906, Congress approved an act that provided for the territory of Oklahoma and the Indian Territory to combine and become the State of Oklahoma. The Proclamation of Statehood was actually signed by President Theodore Roosevelt on November 16 of the following year. Prior to Statehood, all or parts of the study area were a territory of the United States; and were earlier, subject to the governments of Spain, Mexico, and the Republic of Texas.

No Man's Land, or the panhandle as it is generally known today, is the only part of the present State of Oklahoma that was never part of Indian Territory. It was added to the Oklahoma Territory by the Organic Act of 1899. At Statehood, it was divided into three counties: Beaver, Texas, and Cimarron.

Initially, Harper, Woods, Ellis, Woodward, and Dewey counties were part of Indian Territory. Harper, Woods, Woodward, and most of Ellis formed the western end of the Cherokee Outlet which was later opened for homesteading by a land run in September 1893. Dewey and the southern portion of Ellis counties, were part of the Cheyenne-Arapaho Reservation. The Cheyenne-Arapaho surplus lands were opened to settlement by a land run in April 1892.

In the Late Prehistoric Period, various cultures practiced horticulture along the waterways in the study area. Earlier cultures such as Clovis and Folsom had hunting and gathering type economies; Clovis occupation of the study area dates to circa 10,000 B.C.

SOCIOECONOMIC RESOURCES

Population

The eight-county historic population trend, as determined by the census period of 1930-1980, is shown in table 4.

The region is rural in character with about 60 percent of the population residing in rural areas and 40 percent residing in urban areas. The urban centers are Alva, Guymon, and Woodward. All other communities have less than 2,500 population and are classified as rural.

The 1980 median age for the area ranges from 28.4 years in Woodward County to 36.6 years in Harper County. These median ages compare to a national level of 30.0 years and 30.1 years for the State. Based on census data, more than one-half of the population in the area is between the ages 18 and 64.

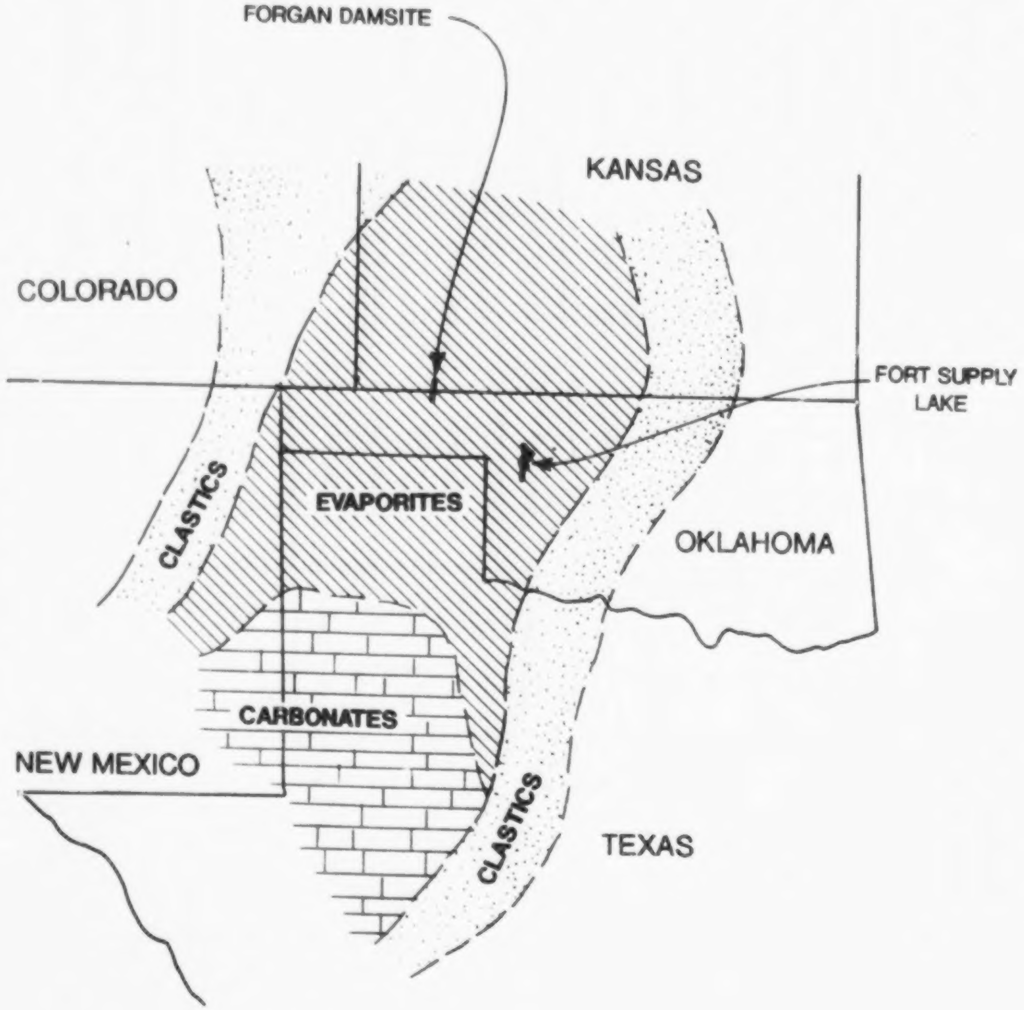

FORGAN DAMSITE
KANSAS
COLORADO
FORT SUPPLY LAKE
CLASTICS
EVAPORITES
OKLAHOMA
CARBONATES
NEW MEXICO
CLASTICS
TEXAS

Figure 2. Principle Facies of Leanardian (Permian) Age in the Southwestern United States

FIGURE 3.—GENERALIZED GEOLOGIC COLUMN
NORTHWEST OKLAHOMA WATER SUPPLY STUDY

SYSTEM	SERIES	GROUP	FORMATION	LITHOLOGY AND ESTIMATED THICKNESS
Quaternary			Surficial Deposits	Sand, silt, clay, gravel in floodplain, channel upper terrace, sinkhole and subsidence basin infillings, and dune sand. Thickness: 50-400 ft.±
Tertiary			Ogallala	Sand and sandstone, silt, gravel, caliche in older fluvial deposits and subsidence basin and sinkhole infillings. Thickness: 0-300 ft.±
	Unconformity			
Paleozoic	Guadalupian (Permian)		Cloud Chief	Redbeds of shale, siltstone, and sandstone and gypsum and anhydrite. Thickness: 100-150 ft.±
		Whitehorse	Dog Creek	Redbeds of shale, siltstone, and sandstone. Thickness: 100 ft.±
			Blaine	Anhydrite, gypsum, and minor shale and siltstone. Thickness: 125 ft.±
			Flowerpot	Salt, anhydrite, minor shale and siltstone. Thickness: 325 ft.±
	Leanardian (Permian)	Wellington	Hennessey	Redbeds of shale and siltstone and salty shale. Thickness: 275 ft.±
			Cimarron	Mostly salt and anhydrite with lesser amounts of salty shale and redbeds. Thickness: 375 ft.±
			Red Cave	Mostly redbeds and gray shale. Thickness: 350 ft.±
				Mostly salt and anhydrite with minor redbeds. Thickness: 600 ft.±
	Wolfcampian (Permian)	Chase		Mostly carbonate rocks and nonredbed shales. Thickness: 500 ft.±

Table 2.—Total land area by county - northwest Oklahoma

County	Total area (acres)	Water area (acres)	Land area (acres)
Beaver	1,151,360	29,740	1,121,620
Cimarron	1,179,520	15,109	1,164,411
Dewey	652,160	30,960	621,200
Ellis	794,880	13,975	780,905
Harper	666,240	12,591	653,649
Texas	1,319,680	18,979	1,300,701
Woods	830,720	8,354	822,366
Woodward	803,200	7,450	795,750
Total	7,397,760	137,158	7,260,602

Source: U.S. Department of Agriculture, Soil Conservation Service, Stillwater, Oklahoma, January 1978.

Table 3.—Agriculture land use by county - northwest Oklahoma (acres)

County	Cropland	Pasture land	Forest land	Range land	Water >40 acres	Water <40 acres	Total
Beaver	453,556	771	1,466	600,723	21,680	8,060	1,086,256
Cimarron	476,811	1,203	75	614,293	12,750	2,359	1,107,491
Dewey	206,250	185	34,158	333,330	30,960	0	604,853
Ellis	187,411	1,317	12,991	533,732	13,180	795	749,426
Harper	199,310	- -	4,388	409,120	9,260	3,331	625,409
Texas	734,069	77	- -	489,861	15,020	3,959	1,242,986
Woods	279,506	6,288	- -	485,938	4,154	4,200	780,086
Woodward	185,825	6,354	1,767	519,392	5,040	2,410	720,788
Regional total	2,722,738	16,195	54,845	3,986,359	112,044	25,114	6,917,295
Percent of total	39.4	0.2	0.8	57.6	1.6	0.4	100.0

Source: U.S. Department of Agriculture, Soil Conservation Service, Stillwater, Oklahoma, January 1978.

Table 4.—Historic population trend by census period 1930-1980 - northwest Oklahoma

County	1980	1970	1960	1950	1940	1930
Beaver	6,806	6,282	6,965	7,411	8,648	11,452
Cimarron	3,648	4,145	4,496	4,589	3,654	5,408
Dewey	5,922	5,656	6,051	8,789	11,981	13,250
Ellis	5,596	5,129	5,457	7,326	8,466	10,541
Harper	4,715	5,151	5,956	5,977	6,454	7,761
Texas	17,727	16,352	14,162	14,235	9,896	14,100
Woods	10,923	11,920	11,932	14,526	14,915	17,005
Woodward	21,172	15,537	13,902	14,383	16,270	15,844
Area population	76,509	70,172	68,921	77,236	80,284	95,361

Source: United States Census

The male to female population ratio is relatively balanced.

Economy

Traditionally, the economy has been based on agricultural and oil and gas production; this trend is expected to continue through the forecast period of this investigation. In 1983, these industries accounted for about 1.5 billion dollars of the area's economy. Other major contributors to the economy are retail sales, wholesale trade, and service industries.

During a 5-year reporting period ending 1983, agricultural production including livestock sales experienced a decline in dollar value. Service industries during the same period also showed a decline in the dollar value of receipts accompanied by a decrease of about 130 establishments. All other industries reported monetary growth during the period.

The economic data for the eight-county area (shown in table 5) indicates that irrigated acreage is a small percentage of the total acres in farms.

In Beaver, Dewey, Harper, and Texas Counties, the value of farm crop sales combined with livestock and poultry sales exceeds other categories of sales; e.g., manufactured goods, wholesale, or retail sales. The value of shipments of manufactured goods is highest in Cimarron and Ellis Counties. The largest contributor to the economic base from retail and wholesale trade sales is Woodward County.

WATER USE

Based on 1984 data, irrigation for agricultural purposes comprised about 87.4 percent of reported water use. Public water systems made up 5.1 percent, livestock 4.6 percent, oil field drilling 1.4 percent, and others 1.5 percent. Water use by major category for individual counties in the study area is provided in table 6.

A review of OEDA data for water consumed by each county in 1984 shows that Texas County consumed 58.2 percent of the total

Table 5.–Economic data - eight counties of northwest Oklahoma

	Beaver	Cimarron	Dewey	Ellis	Harper	Texas	Woods	Woodward
Area (square mile) 1986	1,808	1,842	1,007	1,232	1,039	2,040	1,291	1,242
Population 1986	7,400	3,900	6,300	5,600	4,700	18,000	10,400	21,800
Population per square mile	4	2.1	6.3	4.5	4.5	8.8	8.1	17.6
Households 1985	2,700	1,600	2,500	2,300	2,000	6,800	4,300	8,000
Persons per household	2.69	2.52	2.5	2.5	2.4	2.6	2.3	2.7
Farm earnings ($M) 1984	9.4	16.1	2.7	4.6	13.7	83.1	13.9	2.0
Value of products sold ($M) 1982	56.0	74.0	26.0	23.0	52.0	284.0	47.0	31.0
Average value of products sold per farm	65,459	162,424	36,280	37,322	98,168	357,299	57,464	42,109
Percent from crops	33.9	26.5	48.2	38.6	24.8	15.3	51.8	35.2
Percent from livestock and poultry	66.1	73.5	51.8	61.4	75.2	84.7	48.2	64.8
Number of farms	852	458	792	612	529	795	819	733
Land in farms	1,026,000	1,080,000	583,000	662,000	599,000	1,148,000	736,000	715,000
Total irrigated acres	24,000	45,000	1,000	13,000	6,000	152,000	3,000	6,000
Percent of irrigated to total	2%	4%	0.17%	2%	1%	13%	0.41%	0.84%
Manufacturing-value of shipments ($M) 1982	D	462.8	1.9	1,039.2	D	D	6.4	81.8
Valuation of construction authorized by building permits 1986	25,000	20,000	49,000	X	349,000	1,746,000	689,000	2,729,000
Wholesale trade sales ($M) 1982	31.1	13.1	17.5	19.5	10.7	92.4	40.1	237.6
Retail trade total sales ($M)	12.5	13.7	16.4	22.4	13.3	79.4	59.1	180.1

D = Data withheld to avoid disclosure of information pertaining to a specific organization or individual.
X = Data not available.
Source: County and City Data Book 1988, U.S. Department of Commerce, Bureau of the Census.

Table 6*.—Total of major categories of reported and estimated water use - northwest Oklahoma
(acre-feet)
1985

County	Public water supply		Irrigation[1]		Mining[2] and extractive industries	Oil field[3] drilling and permitted enhanced rec.	Livestock[4]	Others		Total ground	Total surface	Undetermined	Total all	Percent
	Ground	Surface	Ground	Surface				Ground	Surface					
Beaver	620	ϕ	32,122	540	12	1,290	2,039	200	369	32,942	909	3,341	37,192	9.9
Cimarron	560	ϕ	47,413	1,832	ϕ	200	2,464	86	640	48,059	2,472	2,664	53,195	14.1
Dewey	871	ϕ	1,701	ϕ	1	1,250	1,210	90	ϕ	2,662	ϕ	2,461	5,123	1.4
Ellis	1,080	ϕ	14,790	92	ϕ	640	1,031	137	ϕ	16,007	92	1,671	17,770	4.7
Harper	1,064	ϕ	9,776	3,138	112	220	1,680	75	ϕ	10,915	3,138	2,012	16,065	4.3
Texas	5,557	ϕ	206,181	940	80	905	5,556	260	ϕ	211,998	940	6,541	219,479	58.2
Woods	2,050	ϕ	3,741	135	3	320	1,680	80	ϕ	5,871	135	2,003	8,009	2.1
Woodward	7,543	75	6,153	1,186	2,625	460	1,815	250	290	13,946	1,551	4,900	20,397	5.4
Total	19,345	75	321,877	7,863	2,833	5,285	17,475	1,178	1,299	342,400	9,237	25,591	377,230	100.00
Percent (%)	------5.1------		------87.4------		0.8	1.4	4.6	--------0.7--------		90.8	2.4	6.8	100.00	

Source: [1] OWRB 1983, Reported Water Use - Publication 124

[2] All mining and extractive industries surveyed reported ground-water use only

[3] Water use at oil field drilling sites was estimated; no known data exists on ratio of ground-water to surface water

[4] No known data exists on the ratio of ground-water to surface water use for livestock

[*] Table developed by OEDA, 1985.

water used followed by Cimarron with 14.1 percent, Beaver with 9.9 percent, Woodward with 5.4 percent, Ellis with 4.7 percent, Harper with 4.3 percent, Woods with 2.1 percent, and Dewey with 1.4 percent. Figure 4 depicts the reported and estimated water use by county, and the total consumption by source (ground or surface water) within the study area.

M&I WATER SUPPLY SYSTEMS AND CONSUMPTIVE USE

Based on published data and OEDA field surveys conducted in 1985, the study area contains 40 public water-supply systems consisting of 19 rural districts and 21 municipal systems.

Table 7 provides the gallons per capita per day (gpcd) consumptive use by city and county for the year 1984. The gpcd rates were provided by OEDA and are used here for estimating purposes only. It is noted that some individual gpcd rates may be higher than what is considered to be normal.

Table 7.—Gallons per capita per day consumption
by city and county - northwest Oklahoma
1984

sheet 1 of 2

County/city/RWD	Gallons per capita per day	Population served
Municipal		
Beaver		
Beaver	193	1,945
Knowles	--	8
Cimarron		
Boise City	221	1,800
Dewey		
Seiling	260	1,553
Taloga	127	550
Vici[1]	143	800
Ellis		
Arnett	198	714
Fargo	181	409
Gage	266	672
Shattuck[2]	324	1,759
Harper		
Buffalo	284	1,400
Lavern	278	1,563
Texas		
Goodwell[2]	132	663
Guymon	386	8,492
Hooker	156	1,788
Optima	266	133
Texhoma	208	1,275
Woods		
Alva	143	9,500
Waynoka	178	1,488
Woodward		
Mooreland	257	1,532
Woodward[3]	252	15,000

Table 7.—Gallons per capita per day consumption by city and county - northwest Oklahoma.-Continued
1984

sheet 2 of 2

County/city/RWD	Gallons per capita per day		Population served
Rural Water Districts			
Beaver			
Forgan PWA	233		670
RWD #1	148		499
RWD #2	185		120
Cimarron			
Keyes Utility Auth.	179		570
Dewey			
Camargo	--	Served by Dewey Co. RWD #2	--
Leedey	--	Served by Roger Mills RWD	--
Oakwood	--	Served by Dewey Co. RWD #3	--
Putnam	--	Served by Custer Co. RWD #3	--
RWD #1	150		200
RWD #2	--		--
RWD #3	113		774
Ellis (no rural systems)			
Harper			
Rosston	--	No systems, individual wells	--
May	--	No systems, individual wells	--
Harper Co. Rural Water Corp.	124		840
Texas			
Tyrone PWA	243		928
RWD #1	129		150
RWD #2	127		275
Woods			
Capron	--	Served by Woods Co. RWD #1	--
Avard	--	Served by Woods Co. RWD #3	--
Dacoma	--	No systems, individual wells	--
RWD #1	278		350
RWD #2	96		38
RWD #3	224		480
Woodward			
Ft. Supply Utilities	126		530
Mutual	--	Served by Dewey Co. RWD #3	--
Quinlan Comm. Water, Inc.	247		186
Sharon Utilities	133		225
RWD #1	196		478
RWD #2	131		1,100

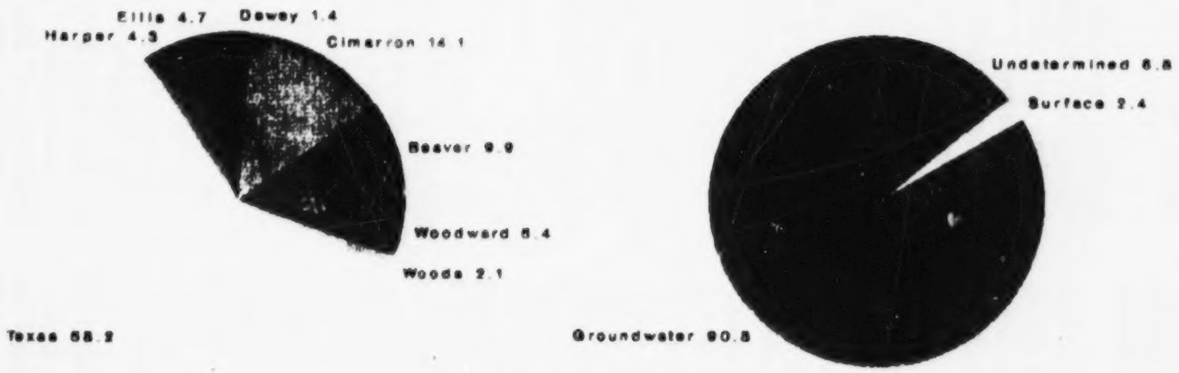
[1] Estimated from number of residential meters

[2] Data provided by the OWRB

[3] Total consumption less large commercial and industrial users

Source: OEDA Field Survey 1985

Figure 4. - 1985 Water Consumption - Eight Counties of Northwest Oklahoma



Water Consumption by County
(Percent)

Water Consumption by Source
(Percent)

Source: Oklahoma Economic
Development Association

PROBLEMS, NEEDS, AND OPPORTUNITIES

GENERAL

Traditionally, the study area has relied on ground water as the principal resource for meeting its municipal, industrial, and agricultural water needs. However, a general decline in water levels throughout the study area has resulted in concern being expressed by several communities as to the reliability of ground water as a long-term domestic water supply source. Most community planners believe that agriculture will continue to be the largest user of ground water and that irrigation demands, over the long term, will increase as the nation's need for food and fiber increases. They also believe that it is prudent for domestic water users to explore the availability of surface water as a potential water supply source for the future.

WATER QUALITY

Water quality problems, primarily high TDS concentrations, are found in surface waters throughout the study area and limit the number of surface-water sites available for development as M&I water supplies.

Ground-water quality is also a growing concern of many city officials in the northeastern counties of the study area. As an example, the town of Freedom located in Woods County was forced to abandoned its wells because of poor water quality and now relies solely on moderately high-quality water supplied by Woodward County Rural Water District Number 1. The City of Waynoka has experienced problems with nitrate levels, with tests showing as high as 15 parts per million (ppm); the maximum allowable level based on EPA Primary Drinking Water Standards is 10 ppm.

Increased ground-water development may create additional water quality problems resulting from brine intrusion into the Ogallala Aquifer.

RECREATION

The availability of water-based recreation varies from being ample in the eastern counties of the study area to almost nonexistent in the northwest or panhandle counties. Fort Supply Lake located in Woodward County provides a wide variety of recreation activities such as boating, swimming, fishing, hunting, camping, wildlife viewing, picnicking, and other leisure activities. Most importantly, the public land and water at Fort Supply Lake provide one of the few places in the area where the general public is guaranteed access to an area where they will be allowed to participate in a variety of activities. Less than 5 percent of the land in Oklahoma is in public ownership; the remainder is privately owned and generally not available for public use. Fort Supply Lake, however, is too shallow to enable motor boats to utilize the entire water surface. Boating activities, such as water skiing, are unsafe on a large portion of the lake.

Other recreation areas within reasonable driving distances from the eastern side of the study area include Great Salt Plains Reservoir, Canton Reservoir, and Foss Reservoir.

Beaver, Cimarron, and Texas Counties of the Oklahoma Panhandle have no surface-water reservoirs suitable for public recreation use. Optima Reservoir, located on North Canadian (Beaver) River in Texas County, has potential for water based recreation; but, since its completion the reservoir has experienced extremely low inflow and has not developed as a useable body of water. Residents of the three counties have often expressed concern over the lack of water-based recreation opportunities in their area and consider this need a high priority.

ECONOMIC CONDITIONS - PRESENT AND FUTURE

The primary industries of the study area are agricultural and cattle production, and oil and gas operations. A relatively large meat packing industry has developed in the Oklahoma and Texas Panhandle and southwest Kansas and is dependent upon large cattle feeding operations and the production of feed grains. This industry is highly dependent upon the Ogallala Aquifer for its water. The Hugoton gas field, which underlies much of northwest Oklahoma, is perhaps the largest gas field in the United States. Oil and gas operations are also highly dependent upon an adequate supply of water.

The Oklahoma Employment Security Commission reported 36,829 persons employed by industrial groups in 1982 for the 8 counties of the study area. The 1982 Census data reported in the *County and State Data Book, 1983*, indicated a total labor force of 43,829 for 1982. The same document shows the 1986 labor force of the area to be 39,146 or a decline of 4,040 persons in 4 years. Table 8 presents study area labor force data and unemployment rates by county for 1982 and 1986.

In 1982 unemployment in the study area was 4 percent and increased to 7.2 percent by 1986. The declining work force and the increasing unemployment rate are indicators of a declining economy during the mid-1980's.

Table 8.—Study area labor force and unemployment rates for 1982 and 1986 northwest Oklahoma

			Unemployed			
	Total labor force		Total		Percent	
County	1982	1986	1982	1986	1982	1986
Beaver	3,444	3,210	84	143	2.4	4.5
Cimarron	1,568	1,666	49	81	3.1	4.9
Dewey	3,572	2,806	158	230	4.4	8.2
Ellis	2,551	3,230	127	178	5.0	5.5
Harper	1,820	2,448	85	116	4.7	4.7
Texas	8,128	9,492	260	554	3.2	5.8
Woods	5,702	5,723	181	197	3.2	3.4
Woodward	16,401	10,571	734	1,340	4.5	12.7
Total	43,186	39,146	1,678	2,839	4.0	7.2

Source: U.S. Census, 1982 and City and County Data Book, 1988 (U.S. Census, 1986)

The trends described above can be expected to continue if no new "boom" development in the gas and oil industry returns to the area.

Development of an improved and assured water supply in the study area would contribute to stabilizing the level of employment by providing an improved quality of life to those who reside in the area. A reliable and high-quality water supply is but one factor that could help provide the incentive for new industries, particularly agriculture-related industries, to take advantage of the industrious labor force of the area and the appeal of its congestion-free rural setting.

FUTURE MUNICIPAL AND INDUSTRIAL WATER NEEDS

Projected Population

The 1980 base population and future population projections for counties and selected towns and communities in the eight-county study area were provided to Reclamation by the Oklahoma Department of Commerce in its 1988 publication *Population Projections for Oklahoma and Its Counties by Age and Sex, and for Its Cities 1980-2010*. The Department also provided the projections for years 2020, 2030, and 2040. However, they pointed out that these projections are unpublished and are made available to Reclamation for planning purposes only. The Department further noted that the reliability of the 2020-2040 projections is limited by the fact that the study area counties have small populations and the time horizon is too far in the future to make precise projections.

Table 9 shows the baseline and projected population data for all counties and communities in the study area. Counties with projected population increases from 1980-2040 are: Beaver, Cimarron, Dewey, Texas, and Woodward. County populations projected to gradually decrease are: Ellis, Harper, and Woods. Overall, the population of the study area is projected to increase from about 76,500 in 1980 to about 84,200 by the year 2040 or a 10 percent gain for the period.

Table 10 shows the 1984 population base and population projections for only those selected communities to be served to the year 2040 by plans evaluated in this study. The selected service area is based on data reflecting 1984 conditions as determined by OEDA (1985). The projections for years 2020 and 2040 were developed by Reclamation using criteria furnished in the Oklahoma Department of Commerce 1988 publication referenced earlier. Again, these projections are unofficial for the same reasons stated earlier. According to these projections, municipal population to be served will increase 14 percent during the period 1984 to 2040. Population served by rural water districts is projected to decrease by 2.5 percent during the same period. The Kansas Water Office projected that the population served by the Liberal Kansas Water System would increase by 23 percent during the period 1984 to 2040.

Future Water Requirements

The water supply analysis presented in this report is based on the assumption that all communities relying on ground water as a source will convert to surface water for their basic supply, while meeting their peak demands with an existing supply source or through the use of water from terminal storage.

Municipal and rural water requirements for selected communities for the years 1984, 2020, and 2040 are shown in table 11. Reclamation estimated 1984 water requirements using OEDA data presented in previous table 7. Water requirements for

Table 9.—1980 base population and population projections, eight counties - northwest Oklahoma

County/community	Population						
	1980	1990	2000	[1]2010	2020	2030	[2]2040
Beaver County	6,806	7,200	7,400	7,550	7,820	8,100	8,390
Beaver	1,939	1,950	2,050	2,150	2,230	2,310	2,390
Forgan	611	650	650	650	660	670	680
Gate	146	150	150	150	150	150	150
Knowles	44	50	50	50	50	50	50
Cimarron County	3,648	3,850	3,900	3,800	3,850	3,900	3,950
Boise City	1,761	2,300	2,450	2,550	2,880	3,250	3,670
Keyes	567	450	450	400	360	320	280
Dewey County	5,922	6,100	6,150	6,200	6,300	6,400	6,500
Camargo	264	250	250	250	250	250	250
Leedey	499	550	550	550	570	590	610
Oakwood	140	150	150	150	150	150	150
Putnam	74	100	100	100	110	120	130
Seiling	1,103	1,150	1,200	1,250	1,300	1,350	1,400
Taloga	446	550	550	600	660	730	810
Vici	845	900	900	950	990	1,030	1,070
Ellis County	5,596	5,450	5,450	5,550	5,530	5,510	5,490
Arnett	714	750	750	750	760	770	780
Fargo	409	350	350	350	330	310	290
Gage	667	550	550	550	520	490	460
Shattack	1,759	1,550	1,500	1,500	1,420	1,340	1,260
Harper County	4,715	4,500	4,400	4,250	4,110	3,970	3,830
Buffalo	1,381	1,350	1,350	1,300	1,270	1,240	1,210
Laverne	1,563	1,450	1,400	1,400	1,350	1,300	1,250
May	89	50	50	50	40	30	20
Rosston	66	50	50	50	50	50	50
Texas County	17,727	17,750	18,450	18,900	19,310	19,730	20,160
Goodwell	1,186	1,200	1,250	1,250	1,270	1,290	1,310
Guymon	8,492	8,750	9,250	9,600	10,000	10,420	10,860
Hardesty	243	250	250	250	250	250	250
Hooker	1,788	1,850	1,900	1,950	2,010	2,070	2,130
Optima	133	100	100	100	90	80	70
Texhoma	785	700	700	700	670	640	610
Tyrone	926	1,000	1,000	1,050	1,090	1,130	1,170
Woods County	10,923	10,000	9,450	8,750	8,130	7,550	7,010
Alva	6,416	5,750	5,350	4,950	4,540	4,160	3,810
Avard	51	50	50	50	50	50	50
Capron	54	50	50	50	50	50	50
Dacoma	226	250	200	200	190	180	170
Freedom	339	300	250	250	230	210	190
Waynoka	1,377	1,250	1,150	1,050	960	880	810
Woodward County	21,172	22,150	23,750	24,750	26,070	27,460	28,920
Fort Supply	559	580	550	600	610	620	630
Mooreland	1,383	1,350	1,450	1,450	1,470	1,490	1,510
Mutual	135	150	150	150	160	170	180
Quinlan	64	50	50	50	50	50	50
Sharon	171	150	150	150	140	130	120
Woodward	13,998	14,500	15,900	17,000	18,140	19,360	20,660
Eight county total	76,509	77,000	78,950	79,750	81,120	82,620	84,250

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[1] Source of county and community populations 1980-2010, "Population Projections for Oklahoma and its Counties by Age and Sex, and for its Cities 1980-2010," Oklahoma Department of Commerce, November 1988.

[2] The Oklahoma Department of Commerce provided unofficial county population projections for years 2020-2040 for Bureau planning purposes, only. These projections are termed unofficial by the Department due to the time span into the future beyond the 1980 base period. County projections were disaggregated to community population projections for years 2020 and 2040 by the Bureau of Reclamation using the methodology prescribed by the Oklahoma Department of Commerce

Table 10.—Projected population for communities served [1] - northwest Oklahoma and southern Kansas

sheet 1 of 3

County/city	[2]1984	2020	2040
	Municipal		
Beaver County			
Beaver	1,945	2,230	2,390
Knowles (less than 50 in 1984)		50	50
Cimarron County			
Boise City	1,800	2,642	3,370
Dewey County			
Seiling [3]	1,553	1,797	1,940
Taloga	550	744	910
Vici	800	913	990
Ellis County			
Arnett	714	760	780
Fargo	409	349	310
Gage	672	567	500
Shattuck	1,759	1,493	1,330
Harper County			
Buffalo [3]	1,400	1,298	1,240
LaVerne	1,563	1,387	1,280
Texas County			
Goodwell	663	709	730
Guymon	8,492	10,000	10,860
Hooker	1,788	2,010	2,130
Optima	133	99	80
Texhoma [3]	1,275	1,139	1,040
Woods County			
Alva [3]	9,500	7,027	5,900
Waynoka [3]	1,488	1,075	910
Woodward County			
Mooreland [3]	1,532	1,644	1,690
Woodward [3]	15,000	19,166	21,830
Municipal - subtotal	53,036	57,099	60,260

Table 10.—Projected population for communities served [1] - northwest Oklahoma and southern Kansas.-Continued

sheet 2 of 3

County/RWD	[2]1984	2020	2040
Rural water districts			
Beaver County			
Forgan Public Works Authority	670	720	740
Rural Water District No. 1	499	580	630
Rural Water District No. 2	120	140	150
Cimarron County			
Keyes Utility Authority	570	290	230
Dewey County			
Camargo			
Served by Dewey Co. RWD No.2	--		
Leedey			
Served by Roger Mills RWD	--		
Oakwood			
Served by Dewey Co. RWD No. 1	--		
Putnam			
Served by Custer Co. RWD No.3	--		
Rural Water District No. 1	200	190	180
Rural Water District No. 2	--		
Rural Water District No. 3	774	730	700
Ellis County			
No rural systems			
Harper County			
Rosston - no systems - individuals wells			
May - no systems - individual wells			
Harper County Rural Water Corp.	840	710	650
Texas County			
Tyrone Public Works Authority	928	1,090	1,170
Rural Water District No. 1	150	150	150
Rural Water District No. 2	275	270	270
Woods County			
Capron			
Served by Woods Co. RWD No. 1			
Avard			
Served by Woods Co. RWD No. 3			
Dacoma - no systems - individual wells			
Rural Water District No. 1	350	260	220
Rural Water District No. 2	38	30	30
Rural Water District No. 3	480	360	310

Table 10.—Projected population for communities served [1] - northwest Oklahoma and southern Kansas.-Continued

sheet 3 of 3

	[2]1984	2020	2040
Rural water districts			
Woodward County			
Fort Supply Utilities, mutually served by Dewey Co. RWD No. 3	530	610	630
Quinlan Community Water, Inc.	186	150	150
Sharon Utilities	225	180	150
Rural Water District No. 1	478	530	550
Rural Water District No. 2	1,100	1,230	1,290
Rural Water District Subtotal	8,413	8,220	8,200
Liberal, Kansas Water System [4]	15,931	18,200	19,600
Total projected population served Municipal and rural	77,380	83,519	88,060

[1] The Oklahoma Department of Commerce provided published county projections for the period 1990-2010. The Department provided unofficial projections for the period 2020 to 2040 due to the number of years beyond it's base period of 1980 for computing projections. City and community population projections for years 2020 and 2040, computed by the Bureau of Reclamation (D-5443), are based on the following formula provided by the Oklahoma Department of Commerce. The geometric growth rate model is:

$P_t = P_0 (1 + r)^t$

where, P_t = projected population at time t,
P_o = base year population at time o,
r = annual rate of growth,
t = time interval.

The Department noted that the reliability of the county projections is limited by the fact that the counties have small population and the time horizon is too far into the future. The reliability of city and community population projections is, likewise, limited.

[2] 1984 base data for Oklahoma entities provided by the Oklahoma Economic Development Association (OEDA) in its table 19 of the "Northwest Oklahoma Water Supply Study," September 1985.

[3] Population served in 1984 exceeds city's 1984 population.

[4] Population served by Liberal Kansas Water System provided by the Kansas Water Office, March 1989.

Table 11.—Municipal and rural water requirements - northwest Oklahoma and southern Kansas

Sheet 1 of 2

County/city	Gallons per capita per day[1]	Acre-feet per year 1984 [2]	Acre-feet per year 2020	Acre-feet per year 2040
Municipal				
Beaver County				
Beaver	193	420	482	517
Knowles (population of less than 50 in 1984)	110		6	6
Cimarron County				
Boise City	221	446	654	834
Dewey County				
Seiling[3]	260	452	523	565
Taloga[3]	127	78	106	129
Vici	143	128	146	159
Ellis County				
Arnett	198	158	169	173
Fargo	181	83	71	63
Gage	266	200	169	149
Shattack	324	638	542	483
Harper County				
Buffalo[3]	284	445	413	394
Laverne	278	487	432	399
Texas County				
Goodwell	132	98	105	108
Guymon	386	3,672	4,324	4,696
Hooker	156	312	351	372
Optima	266	40	29	24
Texhoma[3]	208	297	265	242
Woods County				
Alva[3]	143	1,522	1,126	945
Waynoka[3]	178	297	214	181
Woodward County				
Mooreland[3]	257	441	473	487
Woodward[3]	252	4,234	5,410	6,162
Municipal subtotal		14,448	16,010	17,088
Rural				
Beaver County				
Forgan Public Works Authority	233	175	188	193
Rural Water District No. 1	148	83	96	104
Rural Water District No. 2	185	25	29	31

Table 11.—Municipal and rural water requirements - northwest Oklahoma and southern Kansas—Continued

Sheet 2 of 2

County/RWD	Gallons per capita per day[1]	Acre-feet per year 1984[2]	Acre-feet per year 2020	Acre-feet per year 2040
Cimarron County				
Keys Utility Authority	179	114	58	46
Dewey County				
Rural Water District No. 1	150	34	32	30
Rural Water District No. 3	113	98	92	89
Ellis County				
No rural systems				
Harper County				
Harper County Rural Water Corp.	124	117	99	90
Texas County				
Tyrone Public Works Authority	243	253	297	318
Rural Water District No. 1	129	22	22	22
Rural Water District No. 2	127	39	38	38
Woods County				
Rural Water District No. 1	278	78	81	69
Rural Water District No. 2	96	4	3	3
Rural Water District No. 3	224	120	90	78
Woodward County				
Fort Supply	126	75	86	89
Quinlan Community Water, Inc.	247	52	42	42
Sharon Utilities	133	34	27	22
Rural Water District No. 1	196	105	116	121
Rural Water District No. 2	131	161	180	189
Rural subtotal		1,589	1,576	1,574
Liberal Kansas Water System		3,944	[3]4,540	[3]4,900
Total projected water requirements		19,981	22,126	23,562

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[1] Gallons per capita per day as shown in table 19 of the Northwest Oklahoma Water Supply Study, Oklahoma Economic Development Association, September 1985.

[2] Projected annual acre-feet of water based on population served in 1984, table 19, in the report noted above. The Oklahoma Department of Commerce provided unpublished county population projections for years 2020 and 2040 which it terms unofficial due to the time span beyond its 1980 base. Reclamation computed municipal and rural population projections for years 2020 and 2040.

[3] Kansas Water Office.

years 2020 and 2040 were developed using gallons per capita per day information provided by OEDA (previous table 7) and population projections developed by Reclamation (previous table 10). The total projected annual municipal water requirement for year 2040 is 17,088 acre-feet and the total projected annual rural water requirement for 2040 is 1,574 acre-feet (table 11). Thus, the projected combined total annual water requirement in year 2040 for communities served in Oklahoma is about 18,700 acre-feet. The community of Liberal, Kansas, is projected to need about 4,900 acre-feet by year 2040.

ALTERNATIVE PLAN DEVELOPMENT

INTRODUCTION

Numerous potential reservoir and several stream diversion sites were evaluated in search of an alternative for using surface water to meet the future municipal, rural, and industrial water (MR&I) requirements of the study area. These evaluations resulted in an alternative plan that appears to offer the best potential for meeting the needs of the study area.

POTENTIAL RESERVOIR SITE SCREENING

Numerous reservoir sites were evaluated in a reconnaissance level process of identifying selected sites that might be capable of meeting the future municipal and industrial water requirements of the study area. Initial screening analyses were performed to eliminate potential sites that would not yield water supplies of sufficient quantity and quality. The following criteria were used in the screening process:

1. A site should produce a firm annual yield of greater than 2,000 acre-feet per year.

2. A reservoir site should not be experiencing major reductions in streamflow.

3. A site should not be in close proximity to existing reservoirs that have experienced significant reductions in inflows.

4. Eliminate reservoir sites from further consideration if nearby downstream potential reservoir sites are capable of developing greater yields.

5. The water quality of a site must be at least suitable for irrigation which the OWRB considers to be water with a yearly mean value of 2,100 mg/L or less for total dissolved solids (OWRB, 1989).

The initial screening process resulted in eight reservoir sites for further study. Many of the selected sites have been studied before by the Bureau of Reclamation, the Corps of Engineers, and the Oklahoma Water Resources Board. These selected sites are presented in table 12 and their

Table 12.—Reservoir sites evaluated in preliminary studies

Reservoir sites	River basin
Cold Springs	Upper Cimarron River
Forgan	Middle Cimarron River
Range	North Canadian River
Slapout	North Canadian River
Fort Supply Modification	Wolf Creek
Alva	Salt Fork Arkansas River
Kiowa	Medicine Lodge River
Amber	Elm

locations are shown on figure 5. Fort Supply Lake is an existing lake owned and operated by the Corps of Engineers (COE). One of the alternatives listed in table 12 is the modification of Fort Supply Dam and Lake. The Kiowa and Amber sites, Barber County, Kansas, are located out of the primary study area and therefore are not shown in figure 5.

Appraisal-level evaluations of the potential reservoir sites presented in table 12, except the Kiowa and Amber sites, were performed by Boyle Engineering Corporation, and presented in their 1987 report. Evaluations of the Kiowa and Amber sites were performed by the Bureau of Reclamation and presented in a June 1988 technical memorandum titled *Subappraisal Investigation, Kiowa and Amber Dam and Reservoir Sites, Kansas*.

The other reservoir and diversion sites identified in the screening process were eliminated from further consideration for the following reasons:

1. The Cold Springs site offers the lowest storage to yield benefits and as a result would provide a high cost for each unit of water delivered. In addition, the net annual evaporation from the reservoir would be greater than the annual yield of the reservoir.

2. The Range site on Palo Duro Creek in the North Canadian River basin was dropped because discharges at the site were estimated to be declining at a significant rate. In addition, the State of Texas is proceeding with the development of a dam and reservoir upstream of the Range site. As a result, the quantity of water available for use in the Northwest Oklahoma area would be greatly reduced.

3. The Slapout site was eliminated because this site is downstream of Optima Lake which has not developed a water supply. This condition has occurred because of severely reduced inflows to the reservoir. The problems at Optima combined with the State of Texas' planned development of a reservoir on Palo Duro Creek, which is also upstream of the Slapout site, generates uncertainty about the future availability of flows for storage at the Slapout site.

4. The Alva site was dropped because of poor water quality at the site and because the proximity of the site to M&I demand centers being considered in this study is not favorable.

5. The Kiowa and Amber sites were evaluated as alternatives to the Alva Dam and Reservoir because the quality of water at these sites is significantly better and would require less costly treatment. These sites were also dropped from further consideration because of high development costs and poor proximity to the demand centers being considered in this study.

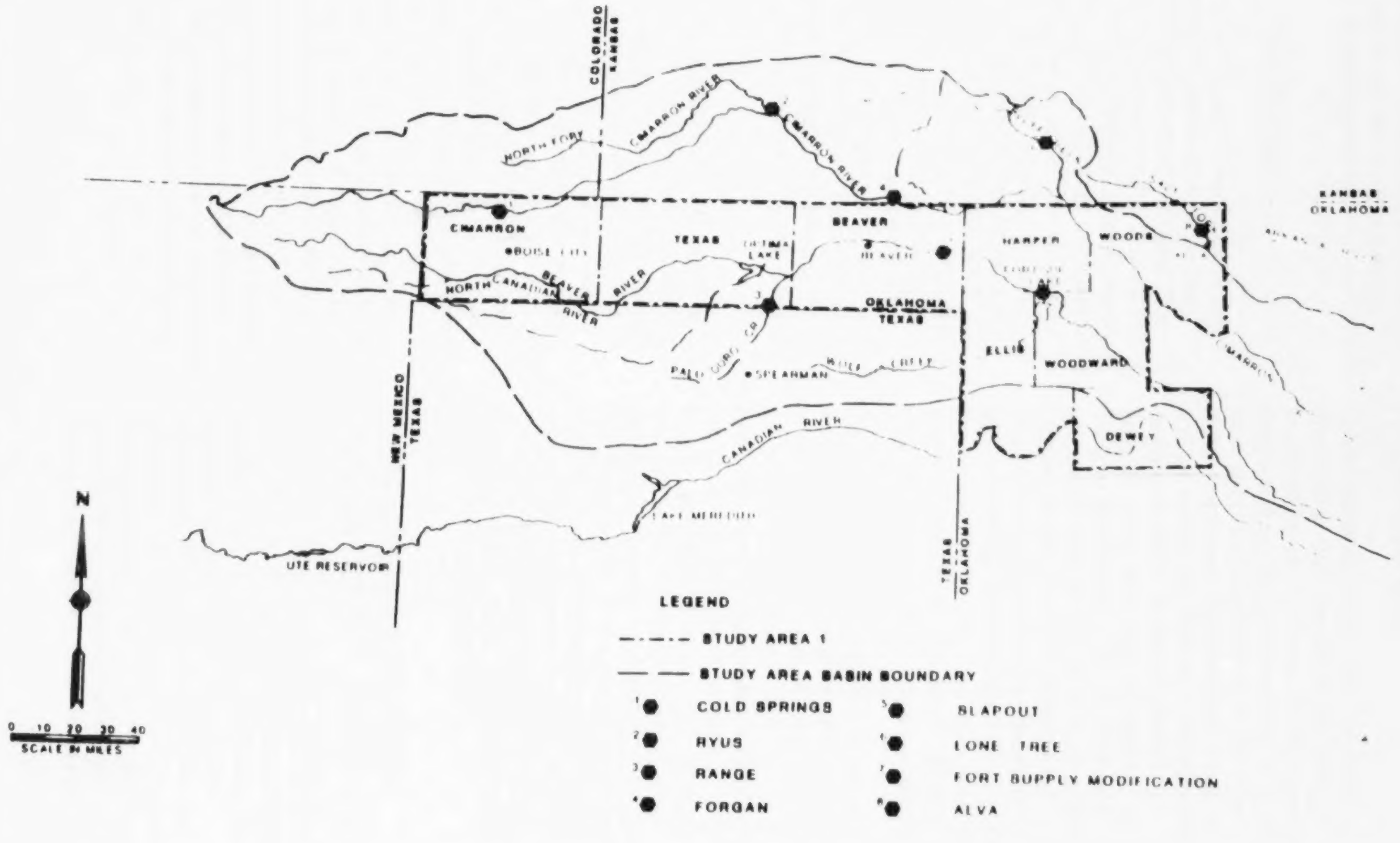
6. The proposed Cold Springs Diversion to Optima Reservoir was dropped from further consideration because of the limited yield and the high cost per unit of water delivered.

7. The direct diversion from the Cimarron River near Forgan was dropped from further consideration because the diversion would not develop enough water to meet the identified MR&I regional demands without relying upon a supplemental water supply.

SURFACE DIVERSIONS EVALUATIONS

As an alternative to using surface-water reservoirs as means to meet future MR&I water requirements, two streamflow diversion structures were considered along the Cimarron River. One proposed diversion was located at the Forgan damsite and the other was located at the Cold

FIGURE 5.-POTENTIAL RESERVOIR SITES
NORTHWEST OKLAHOMA STUDY AREA


COLORADO
KANSAS
KANSAS
OKLAHOMA
NEW MEXICO
TEXAS
TEXAS
OKLAHOMA
OKLAHOMA
TEXAS
NORTH FORK
CIMARRON RIVER
CIMARRON RIVER
CIMARRON
BOISE CITY
TEXAS
OPTIMA LAKE
BEAVER
BEAVER
HARPER
WOODS
ALVA
BEAVER RIVER
NORTH CANADIAN RIVER
PALO DURO CR.
SPEARMAN
WOLF CREEK
ELLIS
WOODWARD
DEWEY
CIMARRON
CANADIAN RIVER
LAKE MEREDITH
UTE RESERVOIR
N
0 10 20 30 40
SCALE IN MILES
LEGEND
STUDY AREA 1
STUDY AREA BASIN BOUNDARY
1 COLD SPRINGS
2 RYUS
3 RANGE
4 FORGAN
5 SLAPOUT
6 LONE TREE
7 FORT SUPPLY MODIFICATION
8 ALVA

Springs damsite. Since these are river diversion schemes only, no flat-water recreation would be provided.

Cold Springs Diversion

This diversion concept is based upon the conveyance of water diverted from the Cimarron River near Cold Springs. The water would be carried within a canal the entire distance to Optima Lake. It would be necessary to extend the canal to Optima in order to avoid large depletions along Golf Creek and the North Canadian Rivers. Streams upstream of Optima Lake rarely flow due to depletions from extensive agricultural development. It was estimated that the best possible yield that could be achieved from the diversion would be around 2,400 acre-feet per year. This estimate was based upon a canal capacity of 500 ft^3/s and considers adjustments for diversion efficiencies, canal losses and lake evaporation.

A very rough cost estimate was made of constructing the Cold Springs diversion dam, a gravel-lined canal, cross drainage structures, channel improvements, and storage characteristic improvements at Optima Dam. This estimate was made assuming that water would be carried 27 miles in a canal to Golf Creek where it would flow naturally down to the North Canadian River and then to Optima Lake. Extrapolation of this estimate to the construction of a canal that would pass water all the way to Optima Lake indicated that the cost of delivery of water via this project (including rough estimates of treatment and distribution system costs) would far exceed other alternatives being considered for meeting municipal water demands within the study area. The cost of such deliveries would likely exceed $5,000 per acre-foot.

Forgan Diversion

Reclamation also evaluated a streamflow diversion at the same location as the proposed Forgan damsite. It was proposed that water could be diverted into a pipeline from the Cimarron River and delivered to a water treatment plant where it could be treated before distribution to various M&I demand centers. It was assumed that, because of the high chloride content, water diverted from the site would have to be treated through a reverse osmosis process to reduce dissolved solids concentrations. The process would produce approximately 25 percent less water than is diverted into the plant. The Forgan Diversion concept was evaluated as an alternative to the construction of Forgan Dam and Reservoir.

An analysis was performed to compare water requirements against the quantities of water that could be developed from the diversion. It was concluded that the diversion would not provide a sufficient amount of water to meet projected MR&I requirements and treatment plant waste requirements. Water diverted from the river would have to be supplemented during low-flow periods. A source for supplemental water was not identified, but it is likely that some water could come from the Ogallala Aquifer. The quantity of supplemental water required to offset shortages would be about 5,000 acre-feet per year.

SURFACE WATER PLAN EVALUATIONS

A review of the appraisal-level evaluations of the identified reservoir sites and of the potential river diversions resulted in the selection of two sites for higher level evaluation. These sites are Forgan Dam and Reservoir, and the modification of Fort Supply Dam and Lake. The development of these two reservoirs has been identified as having the greatest surface-water potential for meeting the future MR&I needs of the study area. The combined use of these reservoir facilities to meet future MR&I water requirements constitutes the proposed development plan evaluated and presented in this report.

The Forgan site offers the potential to develop a large and reliable MR&I supply from a small storage capacity. The reservoir would also offer opportunities for water-sport recreation. The site is at a convenient location for distribution of water to many of the identified MR&I demand centers in the western part of the study area. One major draw back is that the quality of water flowing past the site exceeds acceptable standards for drinking water and would require significant treatment. Another drawback is that there would be significant impacts to fish and wildlife and important habitats of the reservoir site and hundreds of miles of downstream river channel. A major attribute of the site is that it offers the potential to regulate river flows such that water could be released to the river during certain times of the year to dilute much worse quality water downstream.

The modification of Fort Supply Dam and Lake is attractive because the quality of water in Wolf Creek is good and because development costs would be substantially reduced compared to the construction of a new dam and reservoir. Fort Supply Lake is close to many of the demand centers being considered in the western part of this study area and would provide a significant yield. Modification of the dam and lake would also enhance recreational use of the reservoir.

POTENTIAL SURFACE WATER DEVELOPMENT PLAN

DEVELOPMENT PLAN FEATURES

A plan has been developed to serve the projected year 2040 water needs of selected communities and rural water districts in the eight-county study area and the town of Liberal, Kansas. The potential development plan consists of two municipal, rural, and industrial water distribution units. The Fort Supply Unit would provide about 10 million gallons per day (mgd) or 11,215 acre-feet of treated water to the counties of Dewey, Ellis, Harper, Woods, and Woodward located in the eastern half of the service area. The Forgan Unit would provide about 11 mgd or 12,450 acre-feet of treated water to Liberal, Kansas, and to the counties of Beaver, Cimarron, and Texas in the western portion of the service area. The design of each unit consists of the storage, pumping, conveyance, distribution, and treatment facilities necessary to provide the municipal, rural, and industrial (MR&I) water supply.

The general location of each unit's features is shown on map No. 1473-500-10.

FORT SUPPLY UNIT

Fort Supply Dam and Lake

The project was completed by the COE in 1942 and is located on Wolf Creek in Woodward County, Oklahoma. The existing dam consists of an earthfill embankment, an uncontrolled chute-type spillway, and outlet works which includes an intake structure, egg-shaped conduit, and a stilling basin. The reservoir extends upstream approximately 3 miles and averages about 5,000 feet in width at elevation 2004, which is the top of conservation pool with an area of 1,820 acres and storage capacity of 13,900 acre-feet based on sedimentation studies performed for 1969. The flood control storage to elevation 2028 is 86,800 acre-feet.

Studies performed by the COE in 1980 indicate that the dam spillway is inadequate to handle the probable maximum flood (PMF). Overtopping would begin at 87 percent of the PMF and the dam would be overtopped by 1.7 feet during the peak outflow. The dam could fail by being breached.

The proposed modification plan would increase the conservation pool capacity to obtain an annual yield of 11,500 acre-feet which would serve the projected annual demand of 10 mgd in year 2040. This requires an active conservation storage capacity of 30,000 acre-feet and a top of conservation pool elevation of 2015. This conservation pool elevation accounts for future storage losses due to 25,000 acre-feet of sedimentation and maintains a minimum storage pool of 9,400 acre-feet above elevation 2005. In order to maintain the existing active flood control storage capacity at 86,800 acre-feet, the existing spillway crest would be raised to elevation 2033 by placing a concrete ogee cap on top of the existing ogee weir. An emergency spillway would be constructed to combine with the modified existing service spillway to safely pass the PMF while still maintaining 5 feet of freeboard.

The design and layout selected to safely pass the PMF uses a roller-compacted concrete emergency spillway with a broad-crested weir and stepped spillway chute. The emergency spillway has a crest elevation of 2046.5 and is 4,300 feet long. This spillway would operate only after the service spillway and outlet works are passing 105,000 cubic feet per second (ft^3/s) which is greater than the peak inflow for the 100-year flood.

Existing permanent operation and maintenance facilities would continue to be used. No new facilities would be required.

The proposed modifications to Fort Supply Dam are shown on drawing B-1 located in attachment B.

Generalized Geology

Fort Supply Dam and Lake are situated in the Osage Plains Section of the Central Lowlands Physiographic Province. The section in the region of Fort Supply is a plain of low relief interrupted by east-facing escarpments indicating stronger strata in a mass of weaker rocks which dip westerly.

Fort Supply Dam is founded on Permian-age strata of the Whitehorse Group. In descending order, these rocks belong to the Quartermaster, Cloud Chief, and Rush Springs Formations. The Quartermaster consists of predominantly shale, siltstone, and sandstone, while the Cloud Chief is made up of shale, siltstone, sandstone, and minor gypsum, of both secondary and primary origins. The underlying Rush Springs Formation consists predominately of sandstone, siltstone, and minor shale and gypsum.

Structural features in the area consisting of sinkholes, filled chimneys, and erratic dips attest to solutioning of soluble rocks by circulating ground water and collapse of overlying beds. Insofar as known, these or other geologic features have not threatened the integrity of the dam and reservoir.

Water Rights

According to water rights maps obtained from the Oklahoma Water Resources Board, there are decreed rights of 884 acre-feet of water between Fort Supply Lake and the Seiling gauge which is just above Canton Reservoir. The total decreed right of 884 acre-feet of water is less than 1 percent of the average annual flow of the North Canadian River. Therefore, it is concluded that water rights along the North Canadian River between the confluence of Wolf Creek and Canton Reservoir would suffer no impacts due to the proposed change in Fort Supply Lake operations. However, further study would be needed to determine the impact that changes in operations at Fort Supply Lake would make to water rights on and below Canton Reservoir.

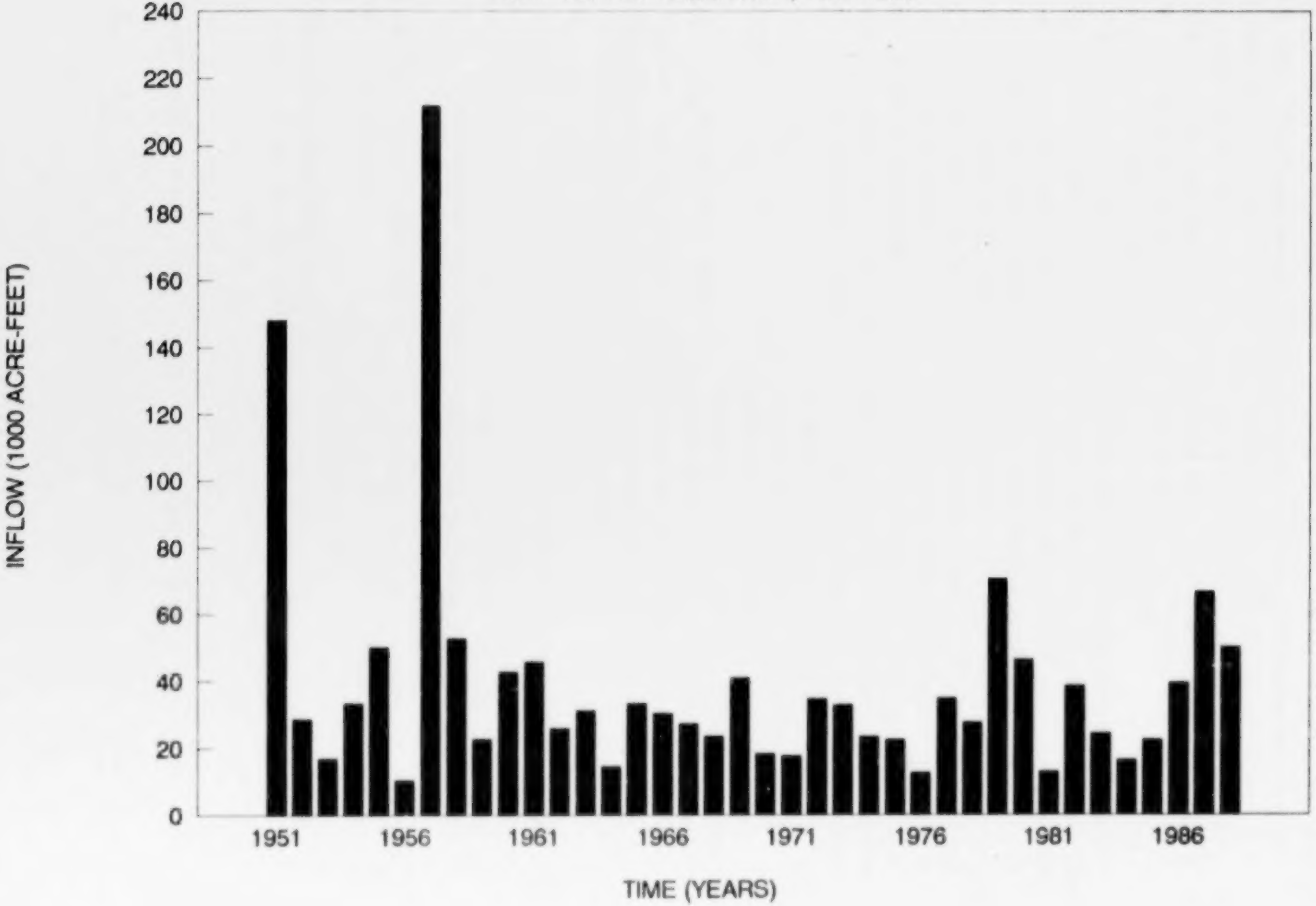
Reservoir Inflow

Since no records of historic inflow to Fort Supply Lake exist, Reclamation computed the reservoir inflow used in this analysis. The computed data was analyzed for apparent reductions in inflow particularly during the period of study 1951-1988. A histograph of historic inflow is presented as figure 6. Inspection of figure 6 indicates that streamflows have not been significantly impacted by upstream development. Therefore, it was concluded by Reclamation that the historic inflows computed for this study are indicative of what could be expected if the present level of development continues into the future and depletions to streamflow do not increase. Average annual inflow to the reservoir is expected to be equal to 39,600 acre-feet.

Figure 6

HISTORIC ANNUAL INFLOW

FORT SUPPLY RESERVOIR, 1951-1988



Sedimentation

The estimated sediment yield rate from the 1969 Fort Supply Lake Sediment Data Summary by the COE is 0.17 acre-feet per square mile per year. This yield would produce a 100-year volume of 25,000 acre-feet. When determining the firm yield of a reservoir, consideration is often given to 50 years of sediment accumulation. Because the reservoir has been in operation for 33 years since the development of area-capacity information used in this study, 100 years of sediment accumulation was considered. A sediment distribution study was performed by Boyle Engineering to determine any decrease in available storage due to the 100-year sediment deposition estimate for the reservoir. Revised area-capacity data were developed and used in the reservoir operations studies.

Reservoir Yield

For the purpose of this study, firm yield is defined as the annual quantity of water that can be provided by the reservoir without experiencing any shortages over the entire period of study.

Firm reservoir yields were computed for numerous conservation capacities. The demand distribution used in each operation study was assumed based on data from a previous Reclamation water supply study performed near the study area.

The following tabulation shows the monthly distribution of annual demand expressed as a percent.

Table 13 presents the results of operation studies performed for the yield analysis of Fort Supply Lake. In each of the operation studies, it was assumed that the reservoir would not be drawn below elevation 2005.38 (capacity of about 9,400 acre-feet) set for minimum recreation storage. This minimum pool was set based on historic minimum end-of-month contents in the reservoir.

Within the Fort Supply Lake operation studies, releases were not made to meet any minimum instream flow requirements that might be required to maintain fishery and wildlife habitat areas below the dam. It was assumed that accretions below Fort Supply Dam, along Wolf Creek, would be adequate to meet such instream flow requirements. At the time of this investigation, no known instream flow requirements existed below Fort Supply Lake. If feasibility-level evaluation studies are performed on the modification of Fort Supply Dam, then detailed studies would have to be performed to determine instream flow requirements and to determine if accretions below the dam would be adequate to meet these requirements.

The conservation storage that would be required to yield 11,500 acre-feet is equal to 30,000 acre-feet. The top of the conservation pool would be at elevation 2015. Average annual net lake evaporation would equal 8,600 acre-feet. The average annual surface area of the reservoir would be 2,600 acres.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7.2	6.1	7.7	7.7	8.8	8.8	12.3	10.5	8.8	8.3	6.6	7.2

Table 13.—Operation studies summary, Fort Supply Lake

Maximum elevation at conservation capacity (feet)	Maximum capacity (acre-ft)	Avg. annual evaporation (acre-ft/yr)	Firm yield (acre-ft/yr)	Min. pool storage capacity (acre-ft)
2007.7	13,000	5,600	0	8,100
2009.3	16,000	6,200	2,000	9,400
2011.2	20,000	7,000	6,000	9,400
2013.4	25,000	7,900	8,700	9,400
2015.3	30,000	8,600	11,500	9,200
2017.0	35,000	9,200	13,700	9,400
2018.6	40,000	9,900	14,400	9,700
2020.0	45,000	10,400	15,300	9,400
2021.4	50,000	11,000	15,600	9,600
2022.8	55,950	11,600	15,800	9,800
2023.8	60,000	12,000	15,900	9,700
2025.9	70,000	12,800	16,000	9,800
2027.9	80,000	13,600	16,100	9,600
2029.7	90,000	14,400	16,200	9,700
2031.4	100,000	15,000	16,300	9,800
2032.0	110,000	15,500	16,500	9,400
2034.6	120,000	16,000	16,500	9,900
2036.1	130,000	16,400	16,600	10,000
2037.5	140,000	16,800	16,800	9,700
2037.9	142,750	17,000	16,800	9,900
2038.8	150,000	17,300	16,900	10,000
2044.9	200,000	19,100	17,600	10,000

Water Quality and Treatment

Water quality data collected by the USGS and by Reclamation indicate that Fort Supply Lake water can be considered to be very hard with moderately high dissolved solids concentrations. The location, field data, and results of lab analysis for water samples taken by Reclamation during the month of November 1989 are presented in attachment A, figure A-1, table A-3, and table A-4.

Existing data do not indicate a problem with organic chemicals in Fort Supply Lake.

Turbidity could be a significant problem in Fort Supply Lake. Data from samples collected by the Oklahoma Conservation Commission show the lake water to be turbid (see attachment A, table A-5). Their data reflected an overall average turbidity of 42.6 NTU with the summer months having the highest quarterly average of 60.2 NTU. The exact cause of turbidity is unknown; however, algae, suspended solids from upstream agricultural activity, natural soil erosion, wave action, and fluctuating water levels are possible causes. Turbidity could interfere with water treatment processes and result in higher treatment costs than those used in this study.

Based on data gathered during the 1974 National Eutrophication Survey, the EPA classified Fort Supply Lake as eutrophic (see attachment A, table A-6). Eutrophication is the enrichment of a water body with nutrients. Lakes are considered to be eutrophic when chlorophyll-a concentrations are greater than or equal to 40 mg/m^3 (40 µ/L).

The water from Fort Supply Lake can be treated to meet State of Oklahoma standards and National Primary and Secondary Drinking Water Standards (attachment A, table A-1). Primary standards are enforceable standards that public water systems must meet, while a secondary standard is a nonenforceable health based goal.

In addition to the standard treatment process defined by EPA (attachment A), the water will need turbidity reduction and possibly an alternate disinfection method to reduce trihalomethane formation. Reduction of iron and manganese, color, and total dissolved solids may be required to meet secondary standards. Taste, odor, and hardness reduction may also be needed to meet consumer preferences.

The downstream water quality impacts of developing additional water supplies in Fort Supply Lake were not examined in this study.

It is assumed that all water users would share the cost of water treatment.

Distribution System

The Fort Supply Unit distribution system will deliver MR&I water to 28 selected water-user entities in a 5-county area. The system would consist of approximately 333 miles of buried pipe ranging in diameter from 4 to 39 inches, 1 water treatment plant, and 4 pumping plants. A total average water supply of about 10 mgd would be available to serve the system from the modified Fort Supply Lake. Delivery of project water would be made to storage facilities owned by individual communities.

Recreation Features

The public land and water at Fort Supply Lake support a wide variety of recreation activities such as boating, swimming, fishing, hunting, camping, wildlife viewing, photography, picnicking, and other leisure activities. Most importantly, the public land and water provide one of the few places where the general public is guaranteed access to an area where they can participate in all of these leisure activities. Less than 5 percent of the land in Oklahoma is in public ownership; the remaining land is privately owned and generally not available for public use.

All of the developed public facilities around the lake are well maintained. The facilities range in age from the 1940's to late 1980's. The types of recreation-related facilities available include completely equipped and basic campsites, restrooms, showers, boat ramps, telephone service, day use areas, equipped group and individual picnic areas, amphitheater, swimming beaches, shelters, electricity and water service, paved or gravel access roads, and parking areas. Most of the campsites are located in tree-shaded areas along the lake. Man-made shelters are provided where there are no trees.

A small area of privately owned land containing 20 cabins/homes is located within the project boundary. The structures are in various stages of condition and some appear to be unused. The area where these cabins are located was originally public land, but was sold to eliminate the problems generated by having private dwellings on public property.

The Oklahoma Department of Wildlife manages a large area of public land around the lake for recreation and wildlife purposes. The area designated as the Fort Supply Wildlife Management Area provides opportunities for hunting quail, turkey, pheasant, deer, rabbit, and waterfowl. Camping is also permitted in designated areas.

Practically all of the existing public recreation facilities and access roads around Fort Supply Lake would be inundated under the proposed reservoir modification plan. In addition, most of the prime hunting land on the wildlife management area would be flooded.

To mitigate the impacts of reservoir enlargement on recreation facilities and lands, the following actions are proposed:

1. Relocate, replace, or modify all existing recreation facilities as shown in table C-1, attachment C;

2. Relocate all roads inundated and/or develop new roadways for public access to recreation areas;

3. Purchase 2,460 acres of comparable habitat to replace land to be inundated at the wildlife management area;

4. Purchase land on the west side of the lake currently occupied with cabins and convert land use to public camp sites; and

5. Follow the recommendations listed in the Corps of Engineers' letter dated February 12, 1990, (attachment C) concerning standing timber and recreational impacts.

Future annual visitation to the reservoir is expected to be about 325,000 visitor days without the proposed reservoir modification. With the reservoir enlarged and the quality of the recreation experience improved, visitations to the lake will likely increase about 15 percent. Maximum visitation to the lake occurred during the "oil boom" days of the early 1980's and was estimated to be about 900,000 in 1984.

Environmental, Cultural, and Social Aspects

The assessment of potential impacts that may occur with modification of Fort Supply Lake are presented in a separate section of this report.

FORGAN UNIT

Forgan Dam and Reservoir

The damsite is located on the Cimarron River near the Kansas-Oklahoma State line. The structure would be a zoned earthfilled embankment with a gated concrete service spillway, a concrete emergency spillway with a broad-crested weir and a stepped spillway chute, and a concrete tunnel outlet works. The dam would have a maximum height of 93 feet, a crest length of 7,500 feet, and a crest width of 25 feet.

The potential dam is designed to safely pass the PMF having a peak outflow of 552,000 ft^3/s, with an allowance for 3 feet of freeboard, by utilizing a combination of service spillway and an emergency spillway capacity. The service spillway is designed to handle peak outflows of 37,000 ft^3/s from the 100-year flood and flows up to 86,000 ft^3/s during the PMF. The emergency spillway would operate only after the service spillway and outlet works are passing 38,000 ft^3/s which is the peak outflow for the 100-year flood. The capacity of the emergency spillway is 450,000 ft^3/s.

The reservoir created by the dam would extend 5 miles upstream at top of conservation pool elevation 2405.6 and have an average width of about 4,000 feet. The total storage capacity of 129,000 acre-feet would be reduced to 104,000 acre-feet at the end of 50 years with 77,500 acre-feet allocated to the conservation pool. This allows for storage of 25,000 acre-feet of sedimentation during the 50-year economic life of the reservoir. After 50 years, the conservation pool would gradually decrease as additional sediment accumulates.

The plan view and cross sections of the proposed Forgan Dam are shown on figures B-2 and B-3 in attachment B.

The reservoir area and pool elevations are shown on drawing 1473-500-8 located in attachment C.

Damsite Geology

The damsite is located in the High Plains Section of the Great Plains Section of the Great Plains Physiographic Province. Topography of the area is gently rolling.

The Cimarron Valley trends along a line of solutioning of salt, gypsum, and anhydrite in the Permian "redbeds." The solutioning has resulted in extensive subsidence. Numerous subsidence features occur in the dam/reservoir area.

Surficial material in the alluvium and channel deposits not only merely blanket the flood plain, but are reported to also represent local infilling in the subsidence basins and collapse structures. Some sand dunes also occur in the flanks of the flood plain.

Tightness of the basin is not known, and storage has not been estimated. It is probable that disturbed rocks, fissures, solution cavities, and/or caverns occur in the upper bedrock at the damsite.

Seismic Activity

The Crooked Creek Fault is reported to occur in the immediate vicinity of the damsite, probably within 1 mile downstream. The structure trends about N300E and is reported to have displacement down to the west on the order of 200 feet. The fault is also reported to occur along the margin of a large subsidence basin which has been infilled with erosional debris as subsidence took place or is taking place.

No evaluation has been done to determine the maximum credible earthquake. The area appears to be one of light seismic activity with no nearby source areas.

Water Rights

Boyle (1987) concluded that the number of surface water appropriations downstream of the Forgan site on the mainstem and its tributaries were minimal and because of poor water quality, only a small fraction of these appropriated waters would actually be drawn from the Cimarron River. If future study of the site is warranted, then water rights upstream and below the site would be evaluated in detail.

Interstate Compact

The States of Kansas and Oklahoma approved the Arkansas River Basin Compact on August 11, 1935. The compact gives Oklahoma free and unrestricted use of the waters of the Arkansas River Basin within Oklahoma subject to the provisions of the compact and to the following limitation:

> New conservation storage capacity in the Cimarron River Sub-basin within the State of Oklahoma shall not exceed 5,000 acre-feet provided that new conservation storage capacity in excess of that amount may be constructed if specific project plans have been submitted to and have received the approval of the Compact Commission.

At the present time, new conservation development between Kansas and Oklahoma is limited to 10,000 acre-feet. In order to construct Forgan Dam, as proposed in this study, it would be necessary for the two States to reach a new agreement on the allocation of Cimarron River waters and seek approval by the Arkansas River Compact Commission.

Reservoir Inflow

It was observed through the analysis of historic streamflow information that annual flows near the Forgan damsite have been decreasing. Figure 7 presents the historic annual flow at the Forgan site for the period 1943 to 1989. An inspection of historic precipitation data for the same time period indicates that annual precipitation has not deviated from normal patterns. In order to determine why streamflows have been decreasing and to predict how much flows would continue to change over the next 50 years, Reclamation conducted a detailed analysis of the historic flows passing the Forgan site. Daily flow records at the Forgan damsite were developed by combining the records from the two gauges: (1) Cimarron River near Mocane, and (2) Cimarron River near Forgan. The analysis included the separation of baseflow from the daily historic record.

Figures 8 and 9 show the annual baseflow and direct runoff respectively. Early in the period of record, direct runoff contributed a larger percentage of streamflow; however, in recent years, that percentage has been changing. Baseflow now makes up the larger portion of streamflow. It is apparent that direct runoff has significantly been reduced as measured near the Forgan damsite. It can also be seen that baseflow has been showing a steady decline since the mid-1960's. Figure 8 reveals that beginning in 1966, there was a significant increase in baseflow in the river; however, since then baseflow has been steadily declining. This increase in baseflow correlates with large runoff events that occurred in 1965 and 1966 (figure 9). Estimates of direct runoff were also made by subtracting the baseflow estimates from gauged river flows. The baseflow estimates represent water discharged from the alluvial ground-water aquifer to the stream. Direct runoff is the portion of gauged streamflow contributed by storm runoff.

Regional ground-water surface elevations also reflect the relationship between direct runoff and baseflow in the Cimarron River Basin. From historic water level maps developed by Reclamation for the Ogallala Aquifer, it was determined that significant drawdown of the ground-water table occurred between the periods 1966-1976 and 1976-1989. This decrease in ground-water surface elevations correlates well with the observed decrease in flows at the Forgan site. It is important to note that the area of largest drawdown was observed in Kansas where the Cimarron River changes course from northeast to southeast. This area of Kansas experienced significant irrigated agricultural development in the early 1970's. Figures 7, 8, and 9 reflect changes in the flow regime of the Cimarron River which began in the mid-1970's.

In view of the downward trend of flow at the Forgan site, there is uncertainty about what magnitude of flows can be expected in the future. In this study, reasonable estimates were made of what would be the upper, lower, and most likely future condition values for average annual inflow to Forgan Reservoir. These estimates represent the range of uncertainty in the future level of flow at the Forgan damsite.

The most likely total average annual future inflow was estimated to be 32,100 acre-feet. The minimum and maximum possible values were estimated to be 22,000 and 48,300 acre-feet per year, respectively. It

Figure 7

HISTORIC ANNUAL FLOW

FORGAN DAM SITE, 1943-1989

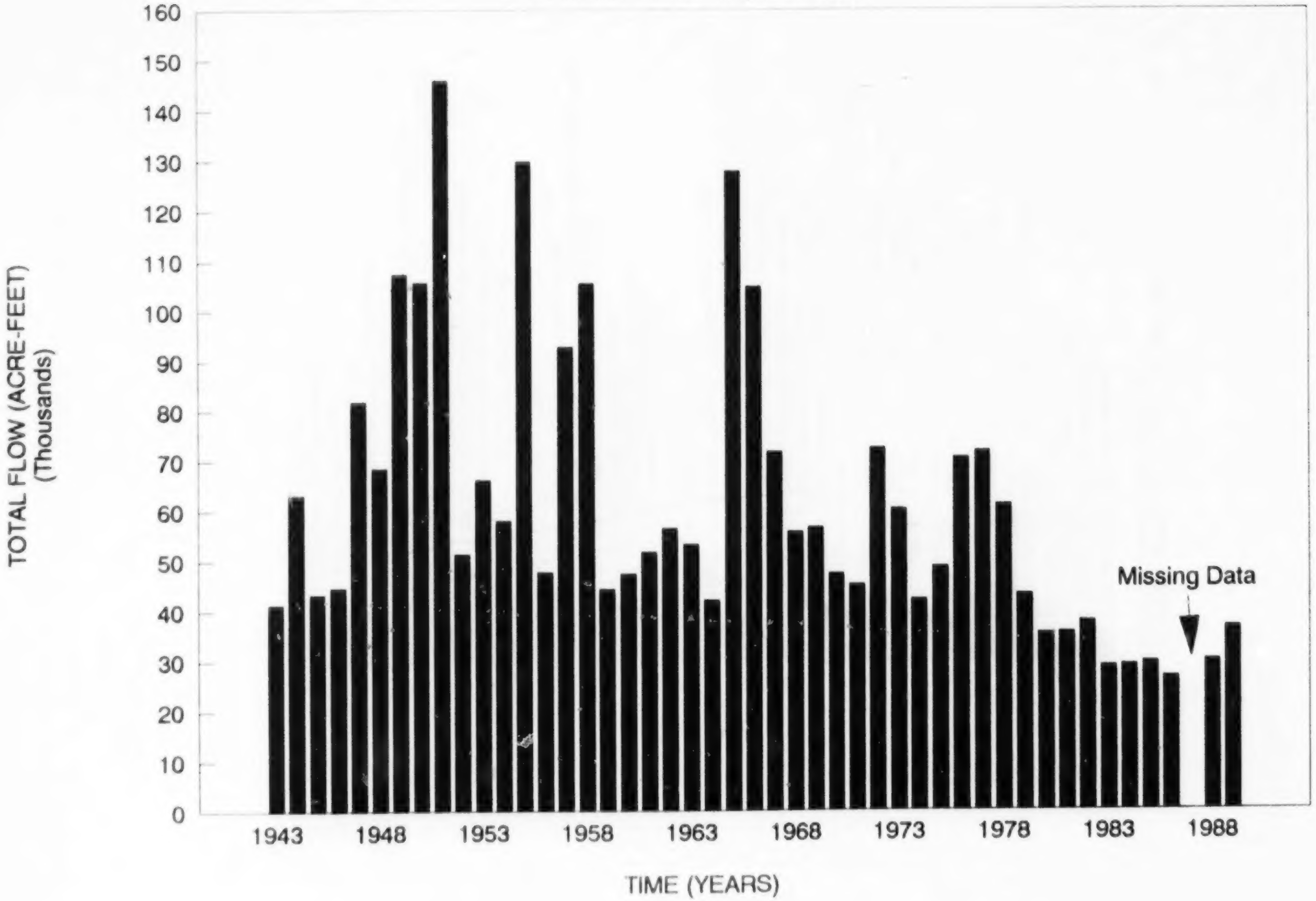


Figure 8

HISTORIC ANNUAL BASE FLOW

FORGAN DAM SITE, 1943-1989

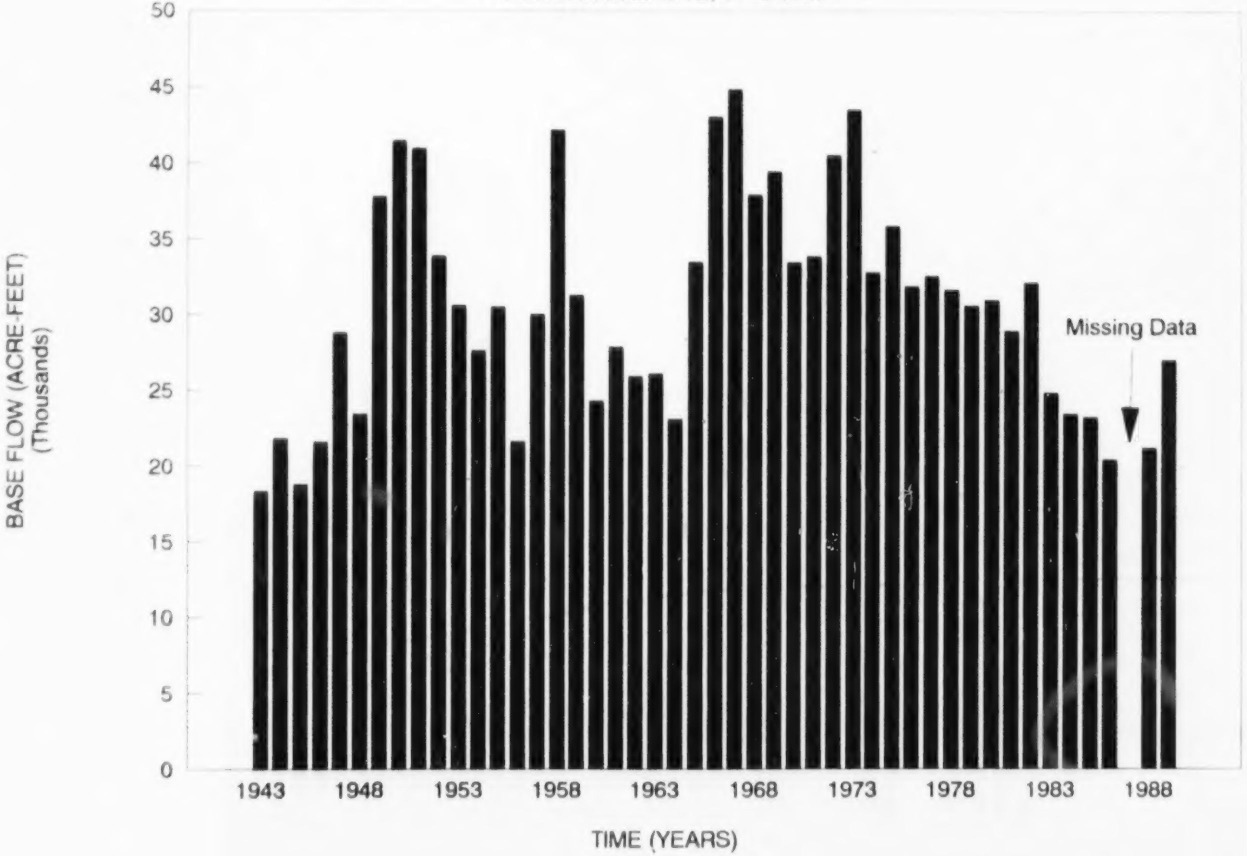
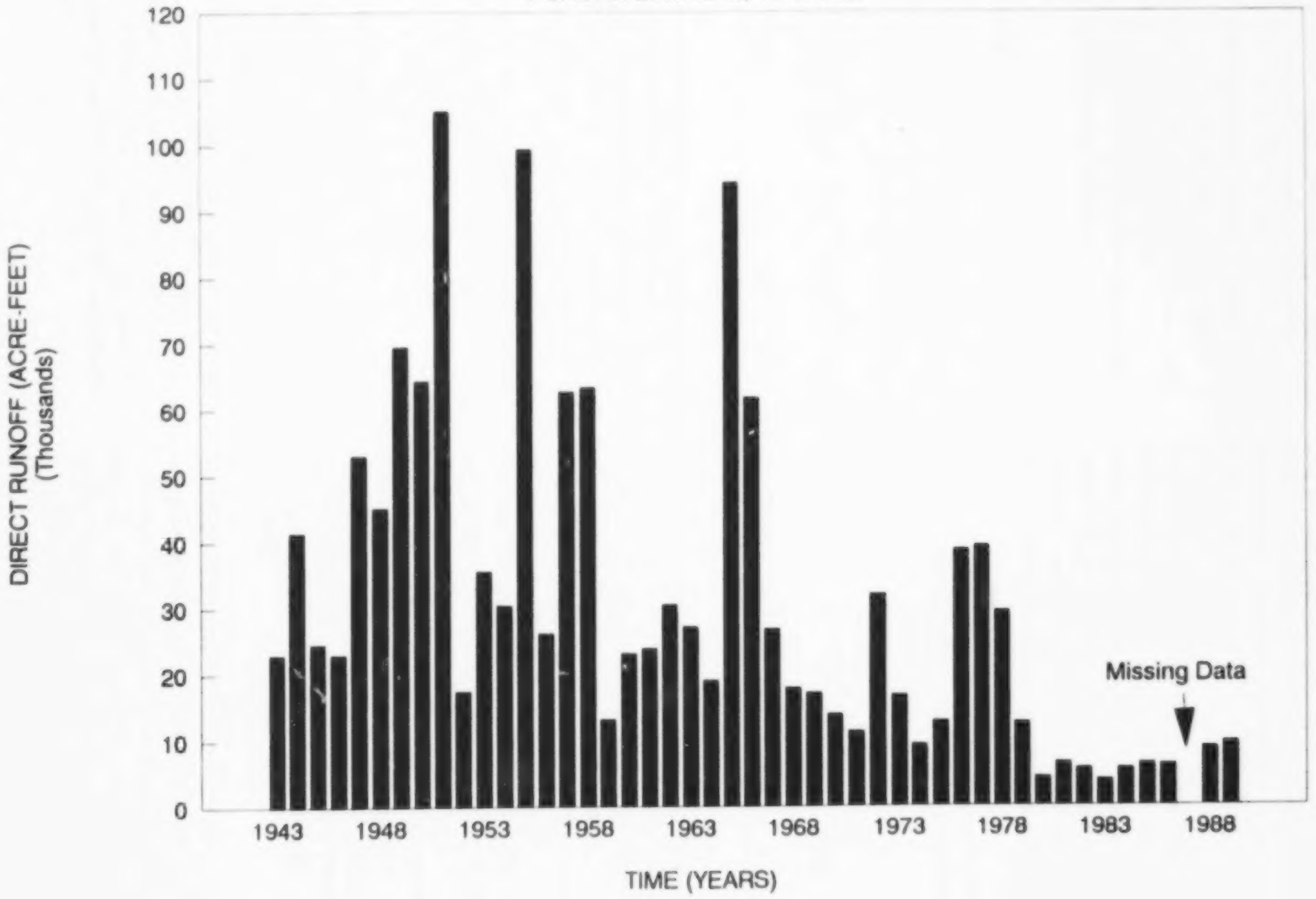


Figure 9

HISTORIC ANNUAL DIRECT RUNOFF

FORGAN DAM SITE, 1943-1989



was estimated by Reclamation that there is a 36-percent chance that the actual average annual future flow at the Forgan damsite will be less than the predicted most likely value of 32,100 acre-feet per year.

The reservoir operation studies performed to estimate the firm annual yield of the proposed Forgan Reservoir were conducted using estimates of monthly flow representative of the most likely minimum and maximum annual inflows.

Sedimentation

For this study, sediment storage requirements were taken from the estimates prepared by Boyle Engineering. Boyle's findings were developed using methods and procedures established by Reclamation guidelines. The estimated sediment yield rate for Forgan Reservoir is 0.12 acre-feet per square mile per year and the 50-year volume is 25,000 acre-feet. Revised area-capacity data reflecting accumulation of the 50-year sediment volume was used in the operation studies for Forgan Reservoir.

Reservoir Yield

Operation studies were performed using several estimates of future inflow to Forgan Reservoir. The operation study results discussed herein reflect the use of the most likely inflow conditions. Within the operation studies, the reservoir was not allowed to draw down below a capacity of 5,000 acre-feet set for minimum recreation purposes.

The conservation storage that would be required to yield 24,100 acre-feet per year is equal to 77,500 acre-feet. The average annual net lake evaporation would equal 8,300 acre-feet. The average annual surface area of the reservoir would be 2,300 acres.

The water delivered from Forgan Reservoir would require treatment to meet drinking water standards. The reservoir releases made in the operation studies include an amount to offset an estimated 25-percent loss resulting from the treatment process.

The following tabulation shows the assumed monthly distribution, expressed in percent, for the MR&I demands.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7.2	6.1	7.7	7.7	8.8	8.8	12.3	10.5	8.8	8.3	6.6	7.2

The 24,100 acre-feet firm annual yield of the reservoir provides for a total MR&I demand of about 17,000 acre-feet including 25 percent for treatment losses. The total quantity of water that would be delivered for MR&I purposes is about 11 mgd (12,450 acre-feet). An additional 7,100 acre-feet annually would be available for other purposes. State officials have suggested that if water above the MR&I demand is available in the reservoir, it should be considered for use as downstream water quality enhancement. A plan that would utilize the 7,100 acre-feet has not been developed.

The U.S. Fish and Wildlife Service (Service) has recommended on a preliminary basis that releases up to 30 ft^3/s during critical periods and 10 ft^3/s during other periods, be made to maintain the fishery downstream of the proposed dam. These releases would equal about 14,500 acre-feet per year.

Within the Forgan Reservoir operation studies, releases were not made to meet any minimum instream flow requirements that might be required to maintain fishery and wildlife habitat areas below the dam. It was assumed that accretions below the dam, along the Cimarron River, would be adequate to meet such instream flow needs. If feasibility studies are performed on the proposed Forgan site, then detailed studies would have to be performed to verify the Service's flow recommendations and to determine if accretions below the dam would be adequate to meet the minimum instream flow requirements.

Water Quality and Treatment

The majority of the water quality data for the Cimarron River at USGS monitoring station near Mocane, Oklahoma, (No. 07157000) was collected before 1965 with a large percentage obtained before 1950. Thus, the data may not represent existing conditions in the river at the Forgan damsite. Also, the data do not appear to accurately reflect the changes in ground-water development and agricultural practices that have occurred over the past 20 to 30 years. For these reasons, Reclamation's analysis focuses on more recent water quality data from two stations near the damsite. These stations are: Cimarron River near Englewood, Kansas (USGS No. 075157580), and State of Kansas station, Cimarron River near Forgan, Oklahoma (No. 000222).

Based on the more recent data, the quality of the water at the Forgan site can be considered to be very hard with high dissolved solid concentrations. The mean values of the more recent data were assumed to be the best available estimates of the water quality conditions that would be found in Forgan Reservoir (see table A-4, attachment A). Known constituents that are expected to exceed National Primary and Secondary Drinking Water Standards are chlorides, dissolved iron, total selenium, total endrin, total lindane, total hardness, turbidity, and total dissolved solids. Water quality parameters proposed by EPA for future regulation that may be exceeded in the reservoir are: total PCB's, total heptachlor, and total epoxide heptachlor.

The present water in the Cimarron River is highly turbid. The topography at the damsite is such that a large portion of the reservoir would be shallow (less than 10 feet deep). Thus, when the reservoir is drawn down, extensive mud flats can be expected to occur. Wind-driven wave action eroding the mud flats would increase the level of turbidity which could interfere with treatment processes.

The reservoir can be expected to be slightly eutrophic. However, the anticipated high turbidity of the reservoir could suppress the growth of aquatic vegetation primarily by inhibiting the penetration of sunlight.

The reservoir could stratify during the spring and fall; but being shallow, the water should attain a uniform temperature during the summer. Turbid waters warm more rapidly at the surface than do clearer waters due to greater solar adsorption near the water surface by suspended particles. Wind induced mixing also would help lessen the potential for stratification.

The water would be treated to meet State of Oklahoma standards and National Primary and Secondary Drinking Water Standards (see attachment A). In addition to the standard treatment process defined by EPA, the water would need dissolved solids and turbidity reduction and possibly an alternative disinfection method to reduce trihalomethane formation. Periodic reduction of iron and manganese, taste, odor, and color may be needed to meet secondary standards. Hardness reduction could be required to meet consumer preferences.

The water treatment plant would be designed with a capacity of 22.8 mgd to handle peak monthly demands. The plant would have two trains consisting of primary and secondary treatment processes plus a reverse osmosis process and brine disposal (evaporation) ponds. The reverse osmosis (RO) process was assumed to have a 75-percent recovery rate with 25 percent of the inflow being converted to brine. The brine would be piped to nearby evaporation ponds which would cover approximately 2 square miles.

The downstream water quality impacts of developing Forgan Dam and Reservoir were not examined in this study.

It is assumed that all water users would share the cost of water treatment.

Distribution System

The water distribution system for the Forgan Unit would supply long-term MR&I water needs to the year 2040 for 16 water-user entities in the project area. Fifteen entities are located in the three Oklahoma counties of Beaver, Texas, and Cimarron; one entity is located in the county of Seward, Kansas. The system would consist of approximately 226 miles of buried pipe ranging in diameter from 4 to 39 inches, 1 water treatment plant, and 4 pumping plants. A total average water supply of 11.117 million gallons per day would be available to serve this system from the potential Forgan Reservoir. Delivery of project water would be made to storage facilities provided by the user.

Recreation Features

The peak recreation season would be May through September during which time approximately 80 percent of the visitation to the reservoir would occur. Since there are no other public reservoirs in the area, the potential Forgan Reservoir would be an extremely popular site. The reservoir would attract persons seeking opportunities to fish, camp, boat, swim, and enjoy nature. Considering the population within a 100-mile radius of the reservoir, it is anticipated that visitor use would be about 250,000 visitor days annually. A visitor day is one person participating in one or more activities over a 12-hour period.

Recreation facilities would be needed as soon as the reservoir is open for public use. The recommended facilities and their location are presented in table C-1 and on drawing 1473-500-8 in attachment C.

The average surface area of water maintained in the reservoir would vary between wet and dry weather cycles. During an average water year, the reservoir would have a surface area of about 2,300 acres and a corresponding depth at the dam of about 43 feet. During a critical or dry period, the reservoir surface area would reduce to about 500 acres and result in a depth at the dam of about 18 feet. This worst condition would occur about once in every 47 years.

Environmental, Cultural, and Social Aspects

The assessment of potential impacts that may occur with development of the Forgan site are presented in a separate section of this report.

DEVELOPMENT PLAN COSTS

Construction, Operation, Maintenance, and Energy Costs

All costs are estimated at January 1990 price levels and are considered subfeasibility level. Unit prices were obtained from Reclamation estimating criteria, recently completed Reclamation projects, and from other technical sources. Construction costs include a percentage factor for: unlisted items (10 percent), contingencies (25 percent), and noncontract costs (30 percent). Energy costs are based on 80 mills per kilowatt hour. Four years would be required to construct project features.

The total construction cost for the Potential Development Plan is $481,500,000; consisting of $140,000,000 for the Fort Supply Unit and $341,500,000 for the Forgan Unit.

Table 14 provides a summary of the total construction costs; the annual energy costs; and the annual operation, maintenance, and replacement (OM&R) costs for the Potential Development Plan. Attachment C, tables C-1 and C-2 provide itemized costs for the Fort Supply and Forgan Units.

Table 14.—Cost summary potential development plan, northwest Oklahoma
(Dollars - January 1990 price level)

Unit	Annual Construction	Annual Energy	OM&R
Fort Supply Lake			
Dam modification	38,600,000	--	21,000
Pipeline system	86,000,000	266,000	357,000
Treatment plant	15,000,000	100,000	500,000
Archeological and historical studies	400,000	--	--
Subtotal	140,000,000	366,000	857,000
Forgan			
Dam and reservoir	127,300,000	--	120,000
Pipeline system	113,000,000	1,370,000	510,000
Treatment plant	100,000,000	2,900,000	3,100,000
Archeological and historical studies	1,200,000	--	--
Subtotal	341,500,000	4,270,000	3,730,000
Total cost	481,500,000	4,636,000	4,587,000

Cost of Water

Fort Supply Unit

The average annual cost of the Fort Supply Unit includes costs for the modification of the dam and reservoir, pipeline system, water treatment plant, mitigation, and archeological and historical studies. Costs that may be incurred as a result of future determinations to make reservoir releases for instream flow requirements are not included.

The average annual cost is based on a repayment interest rate of 10.075 percent for a 50-year repayment period. The average annual cost including construction cost; interest during construction; and annual operation, maintenance, operation, and energy costs for the reservoir delivering 10 mgd would be $18,560,000. As shown in table 15, the average annual cost per thousand gallons of water would be $5.08.

Forgan Unit

The average annual costs of the Forgan Unit include costs for the dam and reservoir, pipeline system, water treatment plant, mitigation, and archeological and historical studies. Costs that may be incurred as a result of future determinations to make reservoir releases for instream flow requirements are not included.

Table 16, analysis A, presents the cost per thousand gallons for MR&I water based on the average annual cost for delivery of 11 mgd or 12,450 acre-feet annually. Of the total yield (24,100 acre-feet), 17,000 acre-feet are required for the MR&I demand including reverse osmosis treatment losses. Therefore, the cost attributable to MR&I water is 71 percent of the total average annual cost. The cost per thousand gallons for this approach is $11.11. It is assumed that a use for the remaining 7,100 acre-feet would be determined at a later date.

Table 15.—Summary of repayment costs - Fort Supply Unit[1]

Yield (annual acre-feet)	11,500
Average annual delivery[2] (acre-feet)	11,215
Construction cost	$140,000,000
Interest during construction	$ 30,453,000
Total investment cost	$170,453,000
Annual investment cost	$ 17,316,000
Annual OMR&E cost	$ 1,244,000
Total average annual cost	$ 18,560,000
Annual cost per acre-foot	$ 1,655.00
Annual cost per 1,000 gallons	$ 5.08

[1] Based on a 50-year repayment period and a repayment rate of 10.075 percent.

[2] Average annual delivery is 11,215 acre-feet with the remainder being lost in the treatment process.

Table 16.—Summary of repayment cost – Forgan Unit[1]

	Analysis A Cost for MR&I portion	Analysis B Total costs
Total annual yield (acre-feet)	24,100	24,100
Yield assignable to M&I (acre-feet)	17,000	[4]17,000
Average annual delivery (acre-feet)[2]	12,450	12,450
Construction cost	[3]$303,643,154	341,500,000
Less recreational costs	$ 3,640,000	6,640,000
Assignable construction cost	$300,003,154	336,787,635
Interest during construction	$ 65,257,000	73,258,000
Total investment cost	$365,260,154	410,045,635
Annual investment cost	$ 37,105,000	41,655,000
Annual OMR&E cost	[3]$ 7,964,647	8,000,000
Total average annual cost	$ 45,069,647	49,655,000
Annual cost per acre-foot delivered	$ 3,620.00	3,988 .00
Annual cost per 1,000 gallons for MR&I deliveries	$ 11.11	12.24

[1] Based on a 50-year repayment period and a repayment rate of 10.075 percent.

[2] Average annual delivery is 12,450 acre-feet with 4,450 acre-feet being lost in the treatment process.

[3] Costs include the water treatment and distribution costs plus 71 percent (17,000/24,100) of the remain costs.

[4] Although MR&I water would receive 71 percent of the total project yield, it would be responsible for all project costs except costs assigned to recreational facilities, as indicated.

For analysis B (table 16), the entire average annual cost of the Forgan Unit is assumed to be attributable to the cost of 17,000 annual acre-feet required for the MR&I demand including treatment losses which would be a delivery of 11 mgd or 12,450 acre-feet annually. For this approach, the cost per thousand gallons is $12.24.

All average annual costs are based on a repayment interest rate of 10.075 percent for a 50-year repayment period.

Attachment D provides a cost-of-water estimate for a Forgan plan without the reverse osmosis treatment and evaporation ponds; and a plan without Lateral 5 which provided deliveries to Keyes and Boise City, Oklahoma.

ENVIRONMENTAL, CULTURAL, AND SOCIAL ASPECTS

ENVIRONMENTAL ASPECTS

Introduction

The Northwest Oklahoma Water Supply Study Area is characterized by a wide diversity of environmental conditions and habitat types. The major ecosystems occurring within the area have been categorized into regional patterns which reflect interactions among climate, mineral availability, physiography, and native vegetation. Table 17 lists the ecoregions and general classifications of vegetation, soils, topography, geology, and climate for the potential Forgan Reservoir and the existing Fort Supply Lake study areas.

Description of Baseline Environmental Resources

Fort Supply Lake Area

Depending upon the classification system used, the Fort Supply area lies either within the Bluestem-grama (Bailey, 1976) or the Central Great Plains (Omernik and Gallant, 1987) ecoregion. The ecoregion is characterized by subhumid climate, dry Mollisol soils, alluvial and sandstone deposits near stream courses, rolling topography, and mixed/sandsage grasslands.

Originating in the Texas Panhandle near Perryton, Wolf Creek flows northeasterly

Table 17.—Ecoregions and generalized classifications of vegetation, soils, topography, geology and climate in the Northwest Oklahoma Water Supply Study Area

Attribute	Forgan Reservoir Site	Fort Supply Lake
Ecoregion (Bailey, 1976)	Gramma-Buffalo Grass	Bluestem-Gramma
Ecoregion (Omernik and Gallant, 1987)	Southwestern Tablelands	Central Great Plains
Biotic District (Blair and Hubbell 1938)	Short-grass Plains	Sand areas
Land-surface form	Tablelands with considerable relief	Irregular plains
Dominant soil resource area	High Plains	Rolling Red Plains
Dominant geology	Alluvium/Sandstone Shale	Alluvium/sandstone
Climate (annual inches precipitation)	Semi-arid (19)	Dry, subhumid (22)

into Oklahoma, is impounded by Fort Supply Dam at river mile 5.5, then flows to its confluence with the North Canadian (Beaver) River. Wolf Creek flows 47.7 miles through Oklahoma and has a total drainage area of 1,735 square miles, of which 98 percent is controlled by Fort Supply Dam.

The following provides a more detailed discussion of environmental resources found within the Fort Supply area. This information was provided by the U.S. Fish and Wildlife Service (Service)(1988) under an interagency agreement with Reclamation.

Terrestrial and Wetland Resources.—The existing Fort Supply project area encompasses 8,079 acres of terrestrial and wetland habitat which are highly interspersed. Overall, habitats at Fort Supply are of higher quality for fish and wildlife than are those at the potential Forgan Reservoir area.

Major terrestrial cover types on the project area include grassland/ shrubland types, mostly sand plum communities and sage-skunkbrush/bluestem-grama grasslands, which provide moderate-to-high value wildlife habitat. Riparian woodlands in the area provide high wildlife habitat value and are dominated by cottonwood overstory, and a midstory of elms, willows, hackberry, chittamwood, mulberries, and rough-leaf dogwood. Various grasses, wild grape, poison ivy, leadplant, and other forbs occur in the riparian ground cover. Approximately 600 acres of the management area are planted with crops such as wheat, millet, and sorghum which provide moderate-to-high value wildlife food and cover. The Corps of Engineers (COE) manages approximately 500 acres of project lands above the existing Fort Supply conservation pool for recreation and public use.

Numerous palustrine wetlands, providing moderate wildlife habitat value, occur in the shallows of Fort Supply Lake. Above and below the lake, many of these wetlands occupy old side channels and depressions adjacent to Wolf Creek and its tributaries. Emergent and submergent aquatic plants include cattails, smartweeds, rushes, pondweeds, and coontail.

Major game species occurring within the Fort Supply project area include white-tailed deer, wild turkey, and bobwhite quail. In addition, the area is also managed for eastern cottontail, mourning dove, ring-necked pheasant, waterfowl, and various furbearers.

Aquatic Resources.—Wolf Creek is primarily a sand-bedded prairie stream with good water quality. Downstream of Fort Supply Dam, the fishery is limited to some degree by variation in flow volume and duration, and also by lack of physical habitat structures. Using field evaluation criteria developed by the Kansas Department of Wildlife and Parks, the Service rated Wolf Creek as having only moderate fishery value. The Service rated Wolf Creek tributaries as low value, because they primarily support sunfish and baitfish populations.

Fish known to occur in Wolf Creek include channel catfish, largemouth and white bass, white crappie, longear and green sunfish, spotted gar, river carpsucker, carp, red shiner, yellow bullhead, and gizzard shad. Reservoir creel surveys (Oklahoma Department of Wildlife Conservation, 1988) indicate that Fort Supply Lake provides about 12,500 angler-days per year. Crappie are the most popular fish, accounting for 65 percent by number and 56 percent by weight of fish taken.

Threatened and Endangered Species.—The endangered bald eagle is the only Federally-listed species known to regularly occur at Fort Supply Lake. The lake is not a significant wintering area, but traditionally supports a few eagles. The Fort Supply area has also been host to migrating whooping cranes; but again, the lake is not a traditional stopping area. There were three confirmed sightings of whooping cranes on the area in 1984.

Sensitive Environmental Resources.—The Fort Supply Wildlife Management Area is a public area, located immediately upstream of the existing reservoir. The area, encompassing 5,418 acres, is managed for fish and wildlife production by the Oklahoma Department of Wildlife Conservation under a license from the COE.

Forgan Reservoir Area.—The following description of the potential Forgan Reservoir area and environmental resources associated with that area has been provided by the Service (1990b).

The Forgan Reservoir area lies within the High Plains section of the Great Plains physiographic province (Self, 1978). Soils on the flood plain of the Cimarron River are primarily the Kanza series consisting of deep, poorly drained, nearly level soils overlaying sand (USDA, 1977). The climate is described as semiarid because the average evapotranspiration is considerably higher than the average precipitation reached each year. Average annual lake evaporation is approximately 63 inches (Hjelmfelt and Cassidy, 1975); whereas, precipitation in Meade County, Kansas, averages about 21 inches annually.

Within the reservoir area, the most prominent topographic feature is the Cimarron River itself and its associated flood plain. The river has a total drainage area of 19,690 square miles and a total length of 692 miles. Four hundred and sixty miles of the river lie within Oklahoma and about 150 miles within Kansas.

Within the river corridor, the Cimarron River has a broad, braided, uniformly sandy channel averaging about 150 feet wide. Cut banks give way to subirrigated wetlands, some of which extend over 1/4 mile from the riverbank. The mean flow of record, as measured at the highway K-23 gauge near the proposed damsite, is 44 cubic feet per second (ft^3/s) with historic monthly averages ranging from 5 ft^3/s to 330 ft^3/s. Heimann and Tortorelli (1988) reported an average annual discharge for the Cimarron River near Mocane, Oklahoma, as 101 ft^3/s, based on 24 years of record. They reported extensive diversions for irrigation above the station. These irrigation diversions are also common in Kansas.

The Cimarron River is the only free-flowing river in Kansas, over 125 miles in length, which does not have any major physical alterations. It is also the only such river in the entire southern Great Plains (Benke, 1990). Additionally, the portion of the river to be impounded by the potential Forgan Dam has been designated by the National Park Service as a "significant free-flowing stream," noted mainly for outstanding scenic, geologic, and historic features.

The potential dam and reservoir would be located in a remote part of Meade County, Kansas, on the Cimarron River, and includes a small portion of Beaver County in Oklahoma. The dam and reservoir would directly affect about three landowners, all part of the expansive Adams (or XIT) Ranch. The management of this area has remained virtually unchanged for nearly 100 years. Cattle ranching and oil production are the primary land uses on this ranch. Limited crop production for winter cattle feeding also occurs. Public access has always been limited due to natural topographic features, lack of roads, and control by private landowners.

Major Habitat Types.—Major vegetative cover types within the Forgan Dam and Reservoir area include grassland (a mixture of sandsage and bluestem-grama prairies), cropland, riparian woodland, and wetlands. Riparian vegetation, unique subirrigated grasslands compose the majority of wildlife habitats within the project area. Meadows, springs, beaver ponds, sandbars, and grassland form a unique river bottom ecosystem along the Cimarron River. Low water tables and upstream water diversions have caused this valuable ecosystem type to become extremely limited in southwestern Kansas.

Within the proposed conservation pool, good grazing management practices on the site allow wildlife habitat to range from fair to good quality. Dominant grassland plant species include sand, big and little bluestem, sand lovegrass, blue and hairy grama, buffalograss, western wheatgrass, sandsage, and broom snakeweed. There is scattered yucca, prickly pear, and sand plum, with Russian olive in lower areas.

Cropland is the next most abundant habitat type and occupies about 7 percent of the total acquisition area. It primarily produces sorghum, alfalfa, and some wheat and is irrigated by center pivots.

Riparian areas of moderate habitat quality are also grazed. They are dominated by scattered willows and scattered mature cottonwood groves within the flood plain. Because of depleted streamflows, and reduction in widespread annual flooding, regeneration of cottonwoods has been suppressed. Subsequently, Russian olive has started rapidly invading. Upland woodlands (shelterbelts) also provide moderate habitat quality.

A variety of wetland types occur on the Forgan site within the Cimarron River flood plain. Some of these include unvegetated sandbars and shifting sand bottom within the river; subirrigated meadows with sedges, rushes, cordgrass, saltgrass, foxtail barley, and spikerushes; a scrub/shrub community consisting of salt-cedar willows, and a mixed herbaceous layer; and other wetlands associated with fresh and saline springs, beaver ponds, and backwater area. Fair to good quality wildlife habitat is provided by about 370 acres of diverse wetlands which occur in the conservation pool.

The Cimarron River flood plain downstream of the Forgan damsite contains numerous wetland types (including riverine unconsolidated bottom, riverine unconsolidated shore, palustrine scrub/shrub, palustrine emergent, and palustrine forested). These provide habitat for a great diversity of resident and migratory species. This riparian zone and its functions and values were described by Stinnett and Smith (1987). In addition to providing wildlife habitat, the riparian zone provides floodwater retention, filtration of sediment, nutrient cycling, and ground-water recharge.

Terrestrial Resources.—A terrestrial resource inventory was not conducted for the Forgan Dam and Reservoir area due to time and funding limitations. Without benefit of a complete terrestrial resource inventory, especially considering the historically limited access the Adams ranch has maintained, a full appreciation and understanding of important species and habitats within the Forgan area cannot be realized. For the purpose of this report, the Service attempted to identify the major terrestrial species believed to inhabit the area of direct impact. Unfortunately, there is little quantitative information currently available on wildlife or their habitats in the Forgan area. The unique interface or edge effect created by the river and various vegetative cover types and their collective value to wildlife form an important ecosystem. Riparian, wetland, and adjacent upland habitats of this kind combine to make one of the most productive wildlife areas in western Kansas, supporting greater numbers and diversity of wildlife than other ecotypes. Low human populations, scarce roads, and strictly restricted access has made the Cimarron River Valley even more valuable to wildlife.

Some species using the grassland habitat in the Forgan area include mule deer, coyote, swift fox, badger, bobcat, ground squirrels, black-tailed prairie dog, black-tailed jack rabbit, desert cottontail, prairie rattlesnake, Texas horned lizard, ornate box turtle, lesser prairie chicken, golden eagle, prairie falcon, burrowing owl, Cassin's sparrow, and horned lark. Lesser prairie chicken numbers are apparently higher in the vicinity of the reservoir site than elsewhere in the region.

Croplands in the Forgan area are used by wildlife primarily in fall and winter. They provide a high energy food source for migratory waterfowl, sandhill cranes, wintering sparrows, meadowlarks, bobwhite quail, ring-necked pheasant, prairie chicken, and white-tailed and mule deer. The value of this habitat is somewhat limited because the cropfields are clustered in one area.

The area's riparian woodland habitat is very important to several species. Large flocks of Rio Grande wild turkeys roost in these trees. Many raptors use the trees for roosting and nesting including redtail and Swainson's hawks, American kestrel, great horned owl, Mississippi kite, and golden and bald eagles. There is unconfirmed golden and bald eagle nesting in the project area. Raccoons, porcupines, woodpeckers, mourning doves, northern and orchard orioles, and many other migratory birds also use the riparian woodland.

The wetlands in the Cimarron River flood plain provide the most diverse habitat in the Forgan area. Because of the permanent water source, most wildlife species in the area spend at least a portion of their time in these wetlands. Some species found here include least tern, spotted sandpiper, snowy plover, ring-necked pheasant, several waterfowl species, bobwhite quail, turkey, beaver, striped skunk, eastern cottontail, cliff swallow, eastern and western kingbirds, common yellowthroat, kingfisher, several other migratory birds, and amphibians and reptiles. Large numbers of sandhill cranes and geese use these areas during migration. Waterfowl production occurs on the wetlands in summer and thousands of mallards use the area during winter. Large beaver ponds, some over two acres, provide duck and geese brood habitat and habitat diversity. The subirrigated meadows provide high quality year-round forage for deer. A good white-tailed deer population exists in the river flood plain and mule deer periodically use this habitat.

Aquatic Resources.—Fishery habitats potentially affected by the Forgan Dam include the Cimarron River, small intermittent streams, permanent springs, seeps, and beaver ponds. Within the reservoir area the Cimarron River has a broad and uniformly sandy aggraded channel. Habitats for fishes consist mostly of long shallow "runs" over shifting sand, interrupted by relatively small, shallow pools and backwaters along banks and exposed sandbars.

Seventeen fish species have been recorded from the Cimarron River in Morton, Grant, Seward, Meade, and Clark Counties (table 18). Two species were introduced (Red River shiner and mosquitofish), and the largemouth bass and channel catfish may no longer be indigenous to this area. Although the Cimarron River maintains only a minimal sport fishery, its waters are of extreme importance to State and potential Federally protected endemic fishes.

Pigg (1987 and 1988) described the fish species and the aquatic habitats of the Cimarron River in Oklahoma. At one site in Harper County, he recorded 16 species and

Table 18.–Fishes recorded in the Cimarron River in Kansas from 1962 to 1987 (Cross et al. 1985)

Fish species	Counties Clark	 Meade	 Morton	 Grant	 Seward
Arkansas River shiner	X				
Sand shiner	X				
Fathead minnow	X				
Plains killifish	X			X	
Red shiner	X	X	X	X	X
Flathead chub			X		
Black bullhead	X		X		
Green sunfish	X		X		
Plains minnow	X	X		X	X
Mosquitofish	X	X		X	X
River carpsucker	X				
Arkansas darter	X	X			X
Red River shiner	X	X			
Channel catfish	X				
Orange-spotted sunfish	X				
Largemouth bass	X				
Suckermouth minnow		X			

at one site in Woods County, he found 19 species. Cumulative fish community rating values for those two sites were poor. Sites further downstream had high ratings, due mainly to the river being larger and there being more diverse fish habitat available. Two species in particular, Arkansas River shiner and Arkansas darter, were of concern in his studies due to an apparent decline in numbers and occurrence in the Cimarron. Changes in flow regime, resulting from a dropping water table and drying up of springs, was cited as the probable cause of decline in numbers and distribution of these species.

Meade and Clark Counties are the only locations where the Arkansas River shiner is believed to persist in Kansas. It has been sampled fairly recently just downstream of the Forgan damsite. It may still also persist in the Cimarron River in Major and Payne Counties in Oklahoma. The Service believes that this fish and the Arkansas darter naturally reproduce in the potential Forgan Reservoir area.

The Arkansas darter has been sampled on the Cimarron River within the potential Forgan Reservoir area in Kansas as recentl as 1987 (Boyd, 1987). It has also been sampled in Harper County, Oklahoma (Pig et al., 1985). Arkansas darters occur primarily on tributary streams near sprin sources where the water temperatures remain generally below 80 °F during summer extremes.

Threatened and Endangered Species.– Federally listed threatened and endangere species which could occur in the Forgan Reservoir area include the piping plover

(*Charadius melodus*), interior least tern (*Sterna antillarum*), bald eagle (*Haliaeetus leucocphalus*), peregrine falcon (*Falco peregrinus*), whooping crane (*Grus peregrinus*), whooping crane (*Grus americana*), and black-footed ferret (*Mustela nigripes*). Each of these species is also listed as threatened or endangered by the States of Oklahoma and Kansas.

The piping plover is a seasonal migrant through the area and uses shallow wetlands and river sandbars for resting and feeding areas. It does not nest in Kansas, but occurs during the spring and fall when it and numerous other shorebird species pass through.

The interior least tern utilizes habitats very similar to those used by the piping plover and it occurs as a nesting species in the Forgan area. A colony is located on sandbars approximately 1 mile east of the Highway K-23 bridge, just downstream of the potential damsite. Many colonies are found along the Cimarron River in Oklahoma.

The bald eagle winters along several rivers in Kansas and Oklahoma and has been observed in the Forgan area. It prefers areas of open water, particularly where large trees provide perches from which it can fish or hunt. Fish and waterfowl comprise its primary winter diet, but small mammals and carrion are also eaten as available.

Peregrine falcons occur as seasonal migrants through Kansas and Oklahoma, occurring where there are concentrations of waterfowl and small birds which compose their prey. Wetlands are a primary habitat type.

Whooping cranes migrate through Kansas and Oklahoma during April and May and again during October and November, using shallow wetlands, wet meadows, and river sandbars. They have been reported from Meade County, along with many sandhill cranes, and could likely occur along the stretch of the Cimarron River where the proposed Forgan Reservoir site is located.

Black-footed ferrets are believed to occur almost exclusively in prairie dog colonies, feeding on prairie dogs and living in their burrows. Ferrets may occur in single prairie-dog towns or in a complex of smaller towns. A complex consists of a cluster of individual dog towns within 4.5 miles of one another. If a town or a complex of 80 acres or more is too be impacted, a ferret survey should be conducted by certified personnel. While it is unknown whether black-footed ferrets still occur in the wild in Kansas and Oklahoma, some of the most promising potential sightings of this animal to be reported in recent years have come from southwestern Kansas in the Cimarron River Valley.

In addition to the species listed in table 19, the following category 1 and 2 candidate species may also occur in the potential Forgan Reservoir area.

Category 1 species are those for which sufficient information exists to support a listing decision. The Arkansas River shiner is the only category 1 species on the above list. Category 2 species are those for which the Service is seeking additional information regarding their biological status. Candidate species have no legal protection under the Endangered Species Act unless and until they become listed. But, consideration of the potential impacts from the Forgan Dam and Reservoir on these candidate species would be consistent with the spirit of Section 7 of the Endangered Species Act.

The Service advises that a listing action for the Arkansas River shiner will be initiated sometime in the next year. While the listing process can take 2 years or more, the belief

Table 19.—Category 1 and 2 candidate species that may occur in the Forgan area

Species	Occurrence
Arkansas River shiner (*Notropis girardi*)	Cimarron River
Arkansas darter (*Etheostoma cragini*)	Springs and marshes along rivers
Texas horned lizard (*Phrynosoma cornutum*)	Sandy soil grasslands
Texas garter snake (*Thamnophis sirtalis annectanus*)	Various habitats
White-faced ibis (*Plegadis chihi*)	Wetlands riverine
Ferruginous hawk (*Buteo regalis*)	Open areas, perches
Mountain plover (*Charadrius montanus*)	Grasslands, fields
Western snowy plover (*C. alexandrinus nivosus*)	Wetlands, riverine
Long-billed curlew (*Numenius americanus*)	Grasslands, wetland
Migrant loggerhead shrike (*Lanius ludovicianus*)	Grasslands, shrubby areas
Kansas bog lemming (*Synaptomys cooperi paludis*)	Wetlands
Swift fox (*Vulpes velox*)	Grasslands

is that the fish warrants Endangered Species Act protection, and listing is expected to be accomplished. The Arkansas darter has also been recommended for listing, although this may not occur until a later date.

Both of these fish have been reported in the Forgan area in the past. They are both listed by the State of Kansas as threatened or endangered and as "species of special concern" in Oklahoma. Kansas lists the following additional species as threatened or endangered and likely to occur in the area: checkered garter snake, eastern hognose snake, eastern spotted skunk, flathead chub, Kansas glossy snake, New Mexico blind snake, snowy plover, Texas longnose snake, and each Federally listed species previously mentioned.

IMPACT ASSESSMENT AND MITIGATION

The primary concern regarding impacts to fish and wildlife resources from water resource developments relates to the amount of high-quality aquatic and terrestrial habitat that would be impacted by plan development and how those losses can be mitigated. Reclamation contracted with the Service for preliminary assessments of habitats likely to be impacted by development of the major components of the Northwest Oklahoma

Water Supply Study and also the amount of mitigation needed to offset those impacts. Their findings and recommendations are presented below.

Fort Supply Dam and Lake Modification Reservoir Area Impacts

Reservoir Area Impacts

Habitat impacts associated with the modification of Fort Supply Dam and Lake were first quantified by the Service in a *Planning Aid Report* prepared in 1988. Following completion of that report, Reclamation revised the proposed elevation for top of conservation pool from 2018 to 2015 feet which, in turn, reduced the total innundation area from 3,887 to 3,350 acres. Since the total amount of habitat likely to be impacted was significantly reduced, Reclamation asked the Service to provide updated estimates of habitat impacts and mitigation requirements. Those updated estimates were provided in a *1990 Planning Aid Report*.

The Oklahoma Department of Wildlife (letter dated March 6, 1990 – attachment C) and the Corps of Engineers (letter dated February 12, 1990 – attachment C) recommended that all timber and brush be left standing or inundated in Fort Supply Lake. This action would provide food, cover, and roosting areas as well as reduce wave action for waterfowl and other birds. The inundated trees and brush would also greatly increase the quality and quantity of fish habitat.

Wetlands and Terrestrial Habitat Impacts

The 1990 Service report determined that the total acreage of wetland and terrestrial habitats occurring within the Fort Supply Lake conservation pool were the same as those presented in the 1988 report (see table 20). As indicated, more than one-half of the area is occupied by low-quality grassland and cropland which would require little if any mitigation. However, a significant portion of the area is composed of riparian woodlands (19.5 percent) and wetlands (11.7 percent). Both of these latter cover types provide high-quality wildlife habitat and would have to be fully mitigated.

The amount of mitigation required for losses of wetland and terrestrial habitat losses is a function of both the acreage and quality of the impacted areas. Projected acreage losses provided by the Service are shown in table 21. At this point, the overall quality of the impacted habitats has not been deter-

Table 20.—Approximate acreage of major habitat types occurring within the Fort Supply Unit area (Percentages shown in parentheses)

Habitat type	Fort Supply Lake		Fort Supply distribution system	
Riparian woodland	726	(19.5)	--	(0.0)
Upland woodland	164	(4.4)	108	(3.4)
Grassland/cropland	2,401	(64.4)	3,037	(95.3)
Wetland	437	(11.7)	43	(1.3)
Totals	3,728	(100.0)	3,188	(100.0)

Table 21.—Estimated acreages of terrestrial habitats which would be lost as a result of modifying Fort Supply Dam and Lake (Developed by the U.S. Fish and Wildlife Service and Bureau of Reclamation)

Habitat type	Service 1988 estimate[1]	Service 1990 estimate[2]	Reclamation estimate[3]
Riparian woodlands	726	1,085	624
Parkland	164	N/A	141
Grassland	1,901	N/A	1,635
Cropland	600	N/A	516
Wetlands	437	598	376
Totals	3,828	1,683	3,292

[1] Based upon a conservation pool elevation of 2018.
[2] Based upon a conservation pool elevation of 2015.
[3] Classified in Service's report as palustrine forested wetlands.

mined. That analysis would have to be done during a latter stage of the planning process using the Service's Habitat Evaluation Procedures (HEP), or other suitable techniques, should the study continue.

However, the Service (1990a) estimated that, based upon the management potential of other similar habitats in the Fort Supply area, approximately 4,208 acres of mitigation would be required to mitigate riparian woodland and wetlands impacts (table 22). Mitigation costs were also provided by the Service (table 22). Costs are based upon land acquisition costs of $600 per acre and initial management costs of $350 per acre.

The mitigation estimates provided by the Service in their *1990 Planning Aid Report* cover not only wetland and riparian habitats within the proposed conservation pool, but also those occurring within the flood pool as well. However, it is unlikely that the functional values of riparian and wetland habitats in the reservoir flood pool would be completely lost and require full mitigation. Also, in estimating the amount of land that would have to be acquired to mitigate lost Habitat Units, the Service based their estimates upon acquiring and managing very high quality (i.e., Habitat Suitability Index [HSI] value of 0.8) replacement habitats. Under these assumptions, management can do little to increase the habitat value of mitigation lands; and consequently, the computational process used by the Service determines that a large acreage of mitigation land is needed to fully recover impacted habitat units.

Based on experience with existing similar projects, Reclamation developed an independent estimate of the impacts and amount of mitigation required to replace wetland and riparian losses for purposes o initial project planning. Reclamation's

Table 22.—Acreage of in-kind mitigation needed to replace terrestrial Habitat Unit losses for high-priority wildlife habitats, Fort Supply Lake modification, based upon U.S. Fish and Wildlife Service and Bureau of Reclamation impact estimates (Dollar cost estimates are provided in parentheses)

Habitat type	Service 1988 estimate	Service 1990 estimate	Reclamation estimate
Riparian woodlands	2,904 ($2,758,800)	2,713 ($2,577,350)	1,248 ($1,185,600)
Wetlands	1,181 ($1,121,950)	1,495 ($1,420,250)	737 ($ 700,150)
Totals	4,085 ($3,880,750)	4,208 ($3,997,600)	1,985 ($1,885,750)

estimate, compared to the Service's estimate in previous tables 21 and 22, is based upon a proportional approach. Since the size of the revised conservation pool is only 86 percent of the initial size, Reclamation estimated habitat acreage losses are 86 percent of those provided by the Service in their 1988 document. Reclamation's estimate also takes into account the fact that actual mitigation lands have not been identified at this point in the planning process. Since the baseline habitat value of lands which will actually be used for mitigation is unknown, mitigation acreage requirements are based upon average habitat quality for all potential mitigation areas throughout the Northwest Oklahoma Water Supply Study area. Mitigation costs were developed using the figures provided by the Service in 1990; i.e., land acquisition costs of $600 per acre and initial habitat development costs of $350 per acre.

It is recognized that it is not possible, during the time frame of this study, to accurately define what the potential project's true mitigation requirement for wetland and riparian habitats will be. Additional work will be needed. Should the study continue in more detail, Reclamation will work closely with the Service to verify the acreage and associated habitat values of the reservoir. However, the acreage and cost estimates provided in previous table 22 probably define the range within which the final mitigation requirement will fall. In addition, a biological assessment will be required outlining potential impacts to threatened or endangered species.

Water Distribution System Impacts

The impact to wetlands resulting from pipeline construction would be relatively minor due to the linear and temporary nature of habitat disturbance. Mitigation of pipeline impacts could best be achieved through increased fish and wildlife habitat management around Fort Supply Lake, rather than further land acquisition.

Acreage of parkland, grassland/shrubland, and cropland impacted by pipeline construction have not been determined. However, these losses are also expected to be minimal and would not require significant amounts of mitigation.

Instream Flows and Aquatic Habitat Mitigation

The proposal to raise Fort Supply Lake would also alter stream outflow into Wolf Creek. Data provided by the USGS indicate that the average annual flow in Wolf Creek, approximately 1.5 miles downstream of Fort Supply Lake, has been 55 ft^3/s since regulation. Reclamation hydrologic analysis for Fort Supply Lake modification indicates that, based upon the historic period of record, 66 percent of all months would experience a zero outflow from the dam.

Studies on other Oklahoma streams have shown that minimum flows of 10 percent of the average annual flow during July through December and 30 percent during January through June are required to prevent degradation of stream habitat. Thus, a minimum continuous instream flow recommendation (Service) for Wolf Creek would consist of 5.5 ft^3/s during July through December and 16.5 ft^3/s during January through June, in order to minimize impacts expected with raising Fort Supply pool levels for water supply purposes. These are preliminary estimates of minimum flow releases and will likely change when additional data have been provided and appropriate instream flow studies are completed.

Potential Forgan Dam and Reservoir

Aquatic Impacts and Mitigation

The following assessment of aquatic impacts associated with the potential development of Forgan Dam and Reservoir was provided by the Service (1990b).

Construction and operation of the Forgan Dam and Reservoir would result in aquatic habitat alterations on the Cimarron River both upstream and downstream of the dam. Forgan Dam would cause the inundation of approximately 7 miles of river to form a broad, deep reservoir. An additional 3 miles would be included in the flood pool. This stretch of the Cimarron River encompasses the majority of the permanent flow remaining in Kansas. The resultant physical changes from riverine to deepwate habitats would favor the proliferation of existing and introduced exotics over native river fishes. It would also directly impact aquatic habitats currently occupied by Arkansas darters and Arkansas River shiners.

Further, flow releases downstream of Forgan Dam would likely contribute more exotic fishes to existing downstream popul tions. Changes in flow volume, timing of release, and temperature, all of which appear to be critical to spawning success fo Arkansas River shiners, are also expected downstream of the dam. Potential flow reductions could alter the hydrology of the flood plain, and disrupt the fluvial process associated with the river system. Flow reductions would also severely impact available fish habitat, and cause further decline in sensitive species.

The seriousness of these impacts, and wh they ultimately mean to the future conservation and recovery of potentially threatened or endangered fishes, both in reservoir site and downstream of the dam is not fully understood at this time. Shou ongoing listing efforts and scientific stud indicate a means by which the dam and reservoir could be constructed, consisten with requirements of the Endangered Species Act, the Service would be asked recommend measures specific to conserv tion and recovery of endangered fish species. Such measures might include creation or modification of habitat downstream of the dam, maximizing flo regimes favorable to life requisites of downstream rare and protected fishes, a funding of research to better evaluate impacts of water depletion, sedimentati and water quality changes on the life history of these fishes.

With respect to nonendangered fish species, the Service believes that mitigation for stream habitat losses due to the Forgan Dam and Reservoir could be partially met by providing a fenced-off riparian/wetland corridor, at least 150-feet wide, along 7.5 miles of river upstream and/or downstream of the dam. This corridor would improve the quality of the river and provide protection from human encroachment. The Service also maintains that additional stream mitigation would be needed in the form of a more natural-flow regime than that tentatively projected by the reservoir's operational plan. Studies on Oklahoma streams (Orth and Maughan, 1981) have shown minimum flows of 10 percent of the average annual flow during July through December and 30 percent during January through June are required to prevent degradation of stream fish habitat. Following these guidelines, a minimum continuous instream-flow recommendation (Service) for the Cimarron River below the Forgan damsite would consist of 10.1 ft^3/s during July through December and 30.3 ft^3/s during January through June. These are preliminary estimates of minimum-flow requirements for the river. More detailed instream flow studies will be necessary if further planning is done on the potential project.

Reservoir Impacts and Mitigation

The Service (1990b) provided Reclamation with estimates of the acreage of each habitat type occurring within the potential Forgan Dam and Reservoir area (table 23). Based upon their estimates, the proposed conservation pool would inundate approximately 3,900 acres, including 370 acres of wetland habitat. They also projected a loss of approximately 1,147 acres of terrestrial habitat between top of conservation pool and flood pool due to periodic flooding for a total terrestrial habitat loss of 5,050 acres.

To estimate mitigation requirements for terrestrial losses at the Forgan site, the Service divided estimated habitat-unit losses by mitigation potential. Habitat units were calculated by multiplying habitat quality (an index between 0.0 and 1.0) for each habitat type occurring within the site times the total acreage of that habitat type impacted. Management potential for each habitat type was the difference between present habitat quality ratings and the

Table 23.—Approximate acreage of major habitat types occurring within the potential Forgan Reservoir conservation and flood pools
(Percentages shown in parentheses)

Habitat type	Conservation pool		Flood pool	
Grassland/cropland	3,375	(86.5)	1,074	(93.6)
Wetlands	370	(9.5)	65	(5.7)
River/sandbar	128	(3.3)	--	
Riparian woodland	--		8	(0.7)
Upland woodland	27	(0.7)	--	
Totals	3,900	(100.0)	1,147	(100.0)

Service's professional estimate of what habitat quality could be achieved through management.

The Service suggests that habitat management of reservoir lands between the take-line and conservation pool could be performed to mitigate grassland impacts associated with the reservoir site. Grassland management would consist of improved grazing management, fencing, planting grassland vegetation on cropland, and similar habitat management practices.

To mitigate aquatic, riparian, and wetland losses within the reservoir site, the Service recommends acquiring additional land adjacent to and upstream of the Forgan site. The mitigation site tentatively identified contains approximately 5,050 acres and is somewhat similar in habitat composition as the Forgan Dam and Reservoir site. To regain habitat losses, the Service believes that several management activities would have to be implemented in this area once the land is acquired. These activities include woodland plantings, fencing, and wetland development.

The Service determined that land acquisition costs for the 5,050 mitigation tract, based upon acquisition costs of $500/acre, would be approximately $2.5 million. In addition, five dwellings are located within the area and would have to be relocated. Wetland development costs were estimated by the Service to be approximately $1.8 million. In total, the Service estimated preliminary mitigation costs for the Forgan Dam and Reservoir site to be $4.99 million (land acquisition and initial development) and annual costs of about $50,000 per year.

Given the time frame within which these mitigation studies were conducted, it is impossible to develop accurate estimates of what actual terrestrial habitat mitigation costs are for the Forgan Dam and Reservoir site. More detailed field studies are needed to accurately evaluate baseline habitat quality and what habitat improvements are possible through management of the mitigation area. The Service believes that the estimates presented above are conservative and that actual mitigation costs could be higher. At a minimum, the high-quality habitats (wetlands and woodlands) within the proposed conservation pool would have to be fully mitigated. Reclamation estimates that approximately 1,300 acres would be needed to mitigate those losses. Using land acquisition costs of $310 per acre developed by Reclamation and the Service's habitat development costs, mitigation for the Forgan Reservoir site would be at least $988,000. These estimates, $4,990,000 and $988,000, provide the range within which actual mitigation costs would likely fall. The lower of these two estimates was used in economic analyses presented elsewhere in this report, since the purpose of the study was to estimate the lowest possible cost of water supplied from Forgan Reservoir.

Downstream Habitat Impacts and Mitigation

Recent Reclamation hydrologic studies indicate that outflow from the Forgan Reservoir immediately below the damsite would be zero for the period November through May each year. This lack of flow would alter the hydrology of the flood plai and disrupt the fluvial processes associate with the river system. The Service (1990b provided the following assessment of how these changes would impact important habitats downstream of the Forgan damsi and probable mitigation needed.

Downstream impacts from the constructi and operation of Forgan Dam can be projected based on studies of other river systems in western Oklahoma. The river corridor would be narrowed due to the absence of flood flows and vegetation encroachment. The extensive unvegetated sandbars would become vegetated mostly by salt-cedar. Nutrient transport from upstream sources would be eliminated and major changes in wetland types within the flood plain would occur. Elimination of scouring flows would encourage land use changes within the flood plain, thus causing an increase of pasture and cropland on what was once wetland. These anticipated impacts could occur for the entire length of the Cimarron River downstream of Forgan Dam.

The expected vegetation changes within the riparian zone of the Cimarron would also cause alteration of the numbers and diversity of wildlife species using the area. Shrub and woodland species would increase, while species utilizing wetland types would be displaced. The projected wetland losses were based on data gathered from the Canadian River by Stinnet and Smith (1987). This data shows an average annual wetland acreage loss along the Canadian River of 1 percent per year over 30 years. Additional wetland losses would be anticipated along the Cimarron due to land use changes expected after alteration of normal flooding regimes.

Based upon these data, the Service (1990b) estimates that the potential Forgan Reservoir would result in the loss or alteration of 37,315 acres of wetland habitat along the Cimarron River downstream of the dam over a 50-year period. They also believe that the only reasonable mitigation for impacts of that magnitude is avoidance, since there are no suitable wetland areas available for consideration as potential mitigation sites. Should the study continue, a major effort will be needed to accurately assess potentially impacted wetland and riparian areas downstream of the Forgan damsite.

Water Distribution System

The Service's (1990b) habitat survey determined that very little high-quality habitat occurs within the Forgan Unit water distribution rights-of-way. The water distribution pipeline would result in temporary loss or alteration of 62 acres of wetlands, 108 acres of upland forest, and 5,374 acres of pasture/cropland. As discussed above for the water distribution system for Fort Supply Unit, these habitat impacts are expected to be linear and temporary in nature. The Service has indicated that these habitat impacts could be mitigated through fish and wildlife management activities on either the Forgan or Fort Supply mitigation lands. No additional land would need to be acquired or developed.

CULTURAL RESOURCES

As a planning procedure, the State Historic Preservation Officer (SHPO) for Oklahoma and Kansas was contacted. Each SHPO was asked to provide information about known (previously recorded) cultural resources at Fort Supply Lake and Forgan Reservoir and potential impacts to them as well as cultural resource methods and procedures to be followed in possible future project development. The COE, Tulsa District, was also asked for information on known cultural resources at Fort Supply Lake.

No cultural resources listed on or determined to be eligible for the National Register of Historic Places are located at Fort Supply Dam and Lake or within the area potentially affected by Forgan Dam and Reservoir. No field surveys have been conducted within the area potentially affected by Forgan; only one small scale survey has been done at Fort Supply Lake. A segment of a "military road" was found in the Fort Supply survey. A historic trash dump, designated as archeological site 34WD74, is the only site known to exist at Fort Supply Lake.

Historical information provides evidence that the Sully and Custer trails and the Camp Supply Road from Kansas to Texas to be located in the Fort Supply Lake area. Historic maps indicate a road traversed the Forgan Reservoir area in 1875; this east-west road jointed a north-south road called the "Hunter's Trail" east of the Forgan damsite. A 1909 atlas shows ranch buildings at the same location as the "XIT Ranch" shown on the USGS Kismet SE quadrangle map (1963 edition), suggesting the ranch has some historical value. These buildings are located just above elevation 2400 and could be within the potential reservoir conservation pool (elevation 2405.6).

The pipeline alignments and pumping plant locations presented in this report are preliminary. If the plan is selected for further study, field surveys of the potential distribution system would be conducted. Adjustments in the location of the pipeline would be made to avoid any known cultural site.

Recommended future work includes comprehensive surveys of and historical studies for both reservoir areas and the distribution systems. Studies at the Forgan site should emphasize the role of ranching; the XIT Ranch buildings should be evaluated for their potential to be listed on the National Register. It is recommended that the Director, Kansas Geological Survey, be contacted for an evaluation of the potential impact of Forgan Reservoir upon paleontological deposits.

SOCIAL

Fort Supply Unit

Income in the form of on-site government and contractor salaries and wages were estimated to total $40.4 million over a 4-year construction period. During the peak year, salaries would be approximately $12 million for both government and contractor labor of which contractor labor earnings account for about 86 percent. In addition to income from salaries and wages spent in the area, an estimated $28.2 million would be spent on construction equipment and materials of which part would be purchased in the local area. A small loss of taxes would occur as some lands would be purchased in fee title. The influx of workers and families is not expected to create an undue burden on the infrastructure of any community due to the relatively small number of construction workers needed.

Employment for the peak year of construction is estimated to be 50 on-site government workers and 260 on-site construction workers. Total employment for the 4-year period is estimated to be about 1,200. It is estimated that 70 percent of the government labor force would move into the area. Whereas, approximately 75 percent of the construction work force would be hired locally or from within a 50-mile radius. The majority of the labor force would be craftsmen and laborers. Census data indicate that only about 11 percent of the currently unemployed work force would be employed in these occupations. Agricultura workers would make up a portion of the labor force since many are receptive to the concept of off-farm jobs. Many of the supervisory personnel would come with the contractor.

A number of structures would require relocation in the proposed take area of the Fort Supply modification plan. There are about 20 cabins and a number of recreation facilities on or near the take area that have been identified as probable candidates for relocation.

Cost, repayment, and the potential problems associated with relocation requirements are among the social issues and concerns that remain to be resolved prior to development of a plan involving Fort Supply modification. Additional data would be gathered to identify the extent of the relocation activities needed.

The potential project would improve local income along with increased employment opportunities. The improved quality of life would induce residents to remain and seek employment locally as is the desire of many natives in the area. Improving local water supply systems would improve, in part, the opportunity for economic development in the area.

Development of the Fort Supply Unit would not result in adverse social impacts.

Forgan Unit

Employment during the construction of Forgan Dam was estimated on the basis of cost comparison with the Fort Supply Dam modification.

The estimated employment for the peak year of construction is 100 on-site government workers and 520 on-site construction workers. Total employment for the 4-year construction period is estimated to be 2,500.

Construction of Forgan Dam would increase local income from on-site government and contractor salaries and wages by about $84 million over the 4-year construction period. During the peak year, salaries would be approximately $25 million for both government and contractor labor of which contractor labor earnings account for about 83 percent. In addition to income from salaries and wages spent in the area, an estimated $58.6 million would be spent on construction equipment and materials of which part would be purchased in the local area.

It is estimated that 75 percent of the construction work force would be hired locally as compared to 30 percent for government workers. The influx of workers and families during construction is not expected to create an undue burden on the infrastructure of any community, although due to the small size of local communities, many workers may be required to locate further away from the construction area, requiring longer commuting distances.

A small loss of taxes would occur to the respective counties. The number of relocations are small, but includes part of the XIT ranch buildings which may have historical significance. Additional data is needed to determine the extent of relocation activities of the ranch buildings.

The general employment opportunities and general improved quality of life is the same under the Forgan Unit as explained for the Fort Supply Unit.

Adverse social impacts would not occur as a result of developing the Forgan Unit.

FINDINGS AND CONCLUSIONS

FINDINGS

The investigation to determine the suitability of surface water resources in the northwest Oklahoma study area for development as a dependable municipal, rural, and industrial (MR&I) water supply finds that:

Water Supply

1. Municipal and rural population projections, developed by the Oklahoma Economic Development Association for designated service communities in the eight-county study area, indicate a total population of about 68,500 by the year 2040. The community of Liberal, Kansas, is projected by the Kansas Water Office to have a population of about 19,600 by the year 2040. Based on these population projections, the projected year 2040 annual water requirement for the communities to be served in the Oklahoma part of the study area is about 18,700 acre-feet. The community of Liberal, Kansas, would require an estimated 4,900 acre-feet annually by the year 2040.

2. The surface water resources of the Cimarron River and of Wolf Creek, tributary to the North Canadian River, could be developed to meet the year 2040 future MR&I water needs of the districts and selected communities to be served in the study area. A development plan consisting of the Fort Supply and Forgan Units has been evaluated for the purpose of providing water to meet those needs.

3. The future dependability of the Fort Supply and Forgan Unit's water supplies is based on a reasonable degree of confidence and is considered to be the most likely future condition. However, if the annual flows at the Forgan damsite continue their present downward trend from the historic higher flow condition, there is the probability that the Forgan Reservoir could only supply something less than the predicted most likely yield of 24,000 acre-feet.

4. The Fort Supply Unit would require the modification of the existing Fort Supply Dam to increase the conservation capacity of the reservoir and the construction of a pipeline delivery system to serve a five-county area in Oklahoma.

5. The Fort Supply Unit could provide an estimated 10 million gallons per day (11,215 acre-feet per year) at an annual cost of about $5 per 1,000 gallons.

6. The Forgan Unit would require construction of a dam and reservoir on the Cimarron River, including a desalting plant, water treatment facilities, and a delivery system to serve a three-county area in the Oklahoma Panhandle and the community of Liberal, Kansas.

7. The Forgan Unit could provide an estimated 11 million gallons per day (12,450 acre-feet per year) at an annual cost ranging from $11 to $12 per 1,000 gallons.

Water Quality

High total dissolved solids concentrations appear to be the greatest limiting water quality factor to the development of surface water resources in the study area. The water to be supplied from Fort Supply Lake and Forgan Reservoir would be suitable for municipal and industrial uses with proper

best copy available

treatment. However, water from Forgan Reservoir would require special treatment to reduce the total dissolved solids concentration to the secondary maximum contaminant level established by the Federal Safe Drinking Water Act Amendments of 1986 (Public Law 93-523, as amended). The concentration levels of constituents regulated by secondary standards are commonly determined by public acceptance rather than the standard. Water treatment costs for water from Forgan could be reduced if the public will accept water with a TDS concentration significantly higher than its standard.

Recreation

1. The present opportunities for water-based recreation vary from adequate in the eastern portion of the study area to nonexistent in the three counties of the Panhandle. Modification of Fort Supply Lake would improve the opportunities for water-based recreation at the lake. An increase in visitor-day use is expected to occur if the lake's conservation storage capacity is increased.

2. Construction of the Forgan Reservoir would significantly improve the water-based recreation opportunities for the panhandle area. Construction of recreation facilities at the Forgan Reservoir could be partially funded by the Federal Water Projects Recreation Act and/or the Land and Water Conservation Fund.

Environment

1. Fort Supply Lake provides habitat for the endangered bald eagle, the only Federally-listed species known to regularly occur there. The lake has also been host to migrating whooping cranes. Modification of the facilities is not expected to impact either species; however, if more detailed studies are conducted, a biological assessment would be included for the bald eagle and whooping crane. Preliminary estimates by the Service suggest that plan impacts to high priority habitats, such as wetlands and riparian area, may be substantial and would require considerable mitigation. The Service also recommends instream flow releases of 16.5 ft^3/s below the dam during January to June and 5.5 ft^3/s during other months.

2. Several Federally listed threatened or endangered species could occur within the Forgan Reservoir area, including the piping plover, interior least tern, bald eagle, peregrine falcon, whooping crane, and black-footed ferret. Each of these species is also listed as threatened or endangered by the States of Oklahoma and Kansas. In addition to these listed species, at least 12 other category 1 or category 2 species may occur in the area. Category 1 species are those for which sufficient information exists to support a listing decision. Category 2 species include those which the Service is currently seeking additional biological information regarding the species' biological status.

The seriousness of potential impacts, and what they ultimately mean to the future conservation and recovery of listed and candidate species, both in the Forgan Reservoir area and downstream, is not fully known at this time. However, changes to least tern habitat would be expected downstream of the dam. Decreased flows would likely decrease the quality and quantity of suitable tern habitat breeding areas many miles downstream of the dam.

If the study continues, a biological assessment will be needed to address potential impacts to each of the species listed above and to make a determination of whether or not there may be an effect on any of those species. If no effect is anticipated, there will be no need for additional endangered species coordination. However, if it is determined that there may be an effect, formal consultation with the Service will be required pursuant to Section 7 of the Endangered Species Act.

The Service recommends full mitigation for terrestrial and wetland habitat loss in the proposed Forgan Reservoir area. The Service also recommends that releases from the dam to maintain instream flows should be 30 ft^3/s during January to June and 10 ft^3/s for other months.

Cultural Resources

1. No archeological or historical sites currently listed on or determined to be eligible to be listed on the National Register for Historic Places are within areas of potential development. Any future investigations would include archaeological and historical studies which would probably show that National Register sites exist in both potential reservoirs. However, none are expected to preclude development at either of the reservoir sites.

2. Recommended future work includes comprehensive archeological surveys of and historical studies for both reservoir areas. Studies at Forgan should emphasize the role of ranching; the XIT Ranch buildings should be evaluated for their potential to be listed on the National Register of Historic Places.

Social

Plan development would not result in adverse social impacts. Social benefits, however, could occur through employment and income opportunities, recreation development, and the opportunity for economic growth in the area.

CONCLUSIONS

1. It can be concluded, with a reasonable degree of confidence, that municipal, rural, industrial, and recreation water requirements within the defined study area can be met for up to 50 years by development of surface water resources.

2. Small independent dams and reservoirs could be constructed to meet some of the local water needs within a small defined area, especially if the dams were operated in conjunction with local ground-water supplies. However, because of the limited quantity of dependable yield that the independent reservoirs could supply, the cost to develop and deliver the water would be considerably more costly than the Fort Supply - Forgan System plan. The small independent dams and reservoirs, therefore, were considered impractical and were eliminated from further consideration at this time.

3. From engineering, hydrological, and financial aspects, the plan that develops water storage through modification of Fort Supply Dam and the construction of Forgan Dam offers the greatest surface water potential for meeting the identified needs of the study area.

4. The effects of plan development to fish and wildlife cannot be quantified with reasonable confidence at this level of study. It is possible that the final mitigation costs could deviate considerably from those presently estimated by Reclamation. More detailed studies would be needed to accurately determine plan induced losses and resultant costs that may be chargeable to the plan.

REFERENCES

Atkinson, S.F.; G.D. Miller; D.S. Curry; and S.B. Lee (1986). *Salt Water Intrusion Status and Potential in the Contiguous United States*. Lewis Publishers, Chelsea, MI. 390 pp.

Bailey, R.G. (1976). *Ecoregions of the United States*. U.S. Department of Agriculture, Forest Service, Ogden, Utah.

Balogh, M.E. (1985). *Remote Sensing Evaluation of Salinity Sources - Cimarron River, Northwest Oklahoma, Vol. 3*. Report TS-AMD - 84029/84561-3. U.S. Environmental Protection Agency, Las Vegas, NV. 53 pp.

Behnke, A.C., (1990). *A perspective on America's vanishing streams*. J. of N. Am. Benthol. Soc. 9(1):77-88.

Blair, W.F. and T.W. Hubbell, (1938). *The Biotic Districts of Oklahoma*. American Midland Naturalist, Volume 20, pp. 425-454.

Boyd, R.L. (1987). *Habitat Management and Population Ecology Studies of the Least Tern in Kansas*, 1987. Kansas Game and Fish Commission Report, Pratt, Kansas.

Boyle (1987a). *Northwest and Western Oklahoma Hydrologic Study, Phase I: Rainfall/Runoff Analyses*. Boyle Engineering Corp., Lakewood, CO.

Boyle (1987b). *Northwest and Western Oklahoma Hydrologic Study, Phase 2: Water Supply Availability*. Boyle Engineering Corp., Lakewood, CO.

Boyle (1988). *Northwest and Western Oklahoma Hydrologic Study, Phase 3: Salinity Investigation*. Boyle Engineering Corp., Lakewood, CO.

Drever, J.I. (1982). *The Geochemistry of Natural Waters*. Prentice-Hall Inc., Englewood Cliffs, NJ. 388 pp.

Dunne, T. and L.B. Leopold (1978). *Water in Environmental Planning*. W.H. Freeman and Company, San Francisco, CA. 818 pp.

EPA, (1973). *Ground Water Pollution in the South Central States*, EPA-R2-73-268. U.S. Government Printing Office, Washington, DC. 181 pp.

EPA, (1978). *A Compendium of National Eutrophication Survey Lakes in the Central United States*, National Eutrophication Survey Working Paper No. 476. Corvallis, OR. 199 pp.

EPA, (1986). *Quality Criteria for Water*. U.S. Environmental Protection Agency, Washington, DC.

EPA (1989). *EPA Ground Water Handbook*. Government Institutes, Inc., Rockville, MD. 212 pp.

Gutentag, E.D.; D.H. Lobmeyer, and S.E. Slagle (1981). *Geohydrology of Southwest Kansas*. Kansas Geological Survey Irrigation Series 7. University of Kansas Publications, Lawrence, KS. 73 pp.

Heinman, D.C. and R.L. Tortorelli, (1988). *Statistical summaries of streamflow records in Oklahoma and parts of Arkansas, Missouri, and Texas through 1984*. U.S. Geological Survey Water Resources Investigations Report 87-4205. 387 pp.

REFERENCES (Continued)

Hem, J.D. (1985). *Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Ed.* U.S. Geological Survey Water - Supply Paper 2254. U.S. Government Printing Office, Washington, DC. 264 pp.

High Plains Associates: Camp, Dresser, and McKee, Inc.; Black and Veatch; Arthur D. Little, Inc. (1982). *Six-State High Plains Ogallala Aquifer Regional Resources Study.*

Hjelmfelt, A.T. and J.J. Cassidy, (1975). *Hydrology for engineers and planners.* Iowa State University Press, Ames, Iowa. 210 pp.

Horak, W.F. and J.D. Stoner (1987). *Oklahoma Ground Water Quality,* U.S. Geological Survey Open-File Report 87-0746. USGS, Denver, CO., 9 pp.

Irwin, J. H. and R. B. Morton (1969). *Hydrogeologic Information on the Glorieta Sandstone and the Ogallala Formation in the Oklahoma Panhandle and Adjoining Areas as Related to Underground Waste Disposal.* Geological Survey Circular 630, U.S. Geological Survey, Washington, DC. 26 pp.

Kansas Water Office, 1987. *Kansas Water Supply and Demand Report,* Kansas Water Office, Topeka, Kansas, April, 1987.

Kansas Water Office, 1987. *A State Water Supply and Demand Methology,* Kansas Water Office, Topeka, Kansas August, 1987.

NAS, (1977). *Drinking Water and Health.* National Academy of Science, Washington, DC.

Oklahoma Economic Development Association, 1985. *Northwest Oklahoma Water Supply Study,* prepared in cooperation with the U.S. Department of the Interior, Bureau of Reclamation, Southwest Region, September, 1985.

Oklahoma Department of Commerce, 1988. *Population Projections for Oklahoma and Its Counties by Age and Sex, and for Its Cities, 1980-2010.* Prepared by Demographic Research and Data Management Research and Planning Division, Oklahoma Department of Commerce, Karen Selland and Mohammed Shahidullah, principal authors. November, 1988.

Oklahoma Department of Health (1982). 305(b) *Technical Report for Oklahoma Water Years 1980-81.* Oklahoma City, Oklahoma. 249 pp.

Oklahoma Department of Wildlife Conservation (1988). *Fish Research and Surveys for Oklahoma Lakes and Reservoirs.* Job No. 13. Development of a population index useful in characterizing crappie population dynamics in large impoundments. Project No. F-37-R-10.

Omernik, J.M. and A.L. Gallant (1987). *Ecoregions of the South Central States.* Environmental Research Laboratory, U.S. Environmental Protection Agency, Corvallis, Oregon. EPA/600/D-87/315.

Orth, D.J. and O.E. Maughan, (1981). *Evaluation of the "Montana method" for recommending instream flows in Oklahoma streams.* Proc. Okla. Acad. Sci. 61:62-66.

OWRB (1980). *Oklahoma Comprehensive Water Plan.* Oklahoma Water Resources Board Publication No. 94.

OWRB (1984). *Oklahoma Water Atlas,* Oklahoma Water Resources Board, Publication No. 120. 186 pp.

REFERENCES (Continued)

OWRB (1989). *Oklahoma Water Quality Standards* adopted by the Oklahoma Water Resources Board on February 14, 1989.

OWRB (1990). *Oklahoma Water Atlas*. Oklahoma Water Resources Board. Oklahoma City, OK. 360 pp.

Pigg, J., (1987). *Survey of fishes in the Oklahoma panhandle and Harper County, northwestern Oklahoma*. Proc. Okla. Acad. Sci. 67:45-59.

Pigg, J., (1988). *Aquatic habitats and fish distribution in a large Oklahoma River*, the Cimarron, from 1976 to 1986. Proc. Okla. Acad. Sci. 68: 9-31.

Pigg, J., W. Harrison, and R. Gibbs, (1985). Records of the Arkansas darter, *Etheostoma craqini* Gilbert, in Harper and Beaver Counties in Oklahoma. Proc. Okla. Acad. Sci. 65:61-63.

Recklow, K.H. and S.C. Chapra (1983). *Engineering Approaches for Lake Management, Volume 1: Data Analysis and Empirical Modeling*. Butterworth Publishers, Boston, MA. 340 pp.

Reclamation, (1989). *Reconnaissance Geologic Report, Forgan Damsite, Northwest Oklahoma Water Supply Project*. Bureau of Reclamation, Oklahoma-Texas Projects Office, Oklahoma City, Oklahoma.

Self, H., (1978). *Environment and man in Kansas*, a geographic analysis. The Regents Press of Kansas, Lawrence. 288 pp.

Service, (1978). *Stream Evaluation Map — 1978*, State of Oklahoma. U.S. Department of the Interior, Fish and Wildlife Service, Denver, Colorado.

Service, (1988). *Planning Aid Report on Modification of Fort Supply Lake and Construction of Alva, Cold Springs, and Forgan Reservoirs*. U.S. Fish and Wildlife Service, Ecological Services Field Office, Tulsa, Oklahoma. 31 pp.

Service, (1990). *Draft Planning Aid Report for Northwest Oklahoma Water Supply Study, Forgan Reservoir Site, Kansas*. U.S. Fish and Wildlife Enhancement Project Office, Manhattan, Kansas. 26 pp.

Service, (1990a). *Fish and Wildlife Mitigation Information on Northwest Oklahoma Water Supply Study*. U.S. Fish and Wildlife Service, Ecological Services Project Office, Tulsa, Oklahoma. 7 pp.

Service, (1990b). *Final Planning Aid Report for Northwest Oklahoma Water Supply Study* - Forgan Dam and Reservoir, Kansas. U.S. Fish and Wildlife Service, Kansas State Office, Manhattan, Kansas. 23 pp.

Stinnet, D. and R. Smith, (1987). *Riparian areas of western Oklahoma* - a special study of their status, trends, and values. U.S. Fish and Wildlife Service and Oklahoma Department of Wildlife Conservation, Oklahoma City, Oklahoma. 80 pp.

USDA (1977). *Soil Survey of Meade County, Kansas*. U.S. Department of Agriculture, Soil Conservation Service and Kansas Agricultural Experiment Station. 63 pp and maps.

ATTACHMENT A
WATER QUALITY DATA

ATTACHMENT A

Water Quality Terms

Water quality is affected by numerous biological, chemical, and physical processes. Acceptable water quality may be water which the public has become accustomed, and acceptance may be tempered by economic considerations. The **Safe Drinking Water Act (SDWA)** is federal legislation which regulates finished drinking supplies. The SDWA applies to all public or privately owned water systems that have 15 or more service connections or that serve more than 25 people. The substances and their standards established by SWDA amendments of 1986 are shown in the **National Primary and Secondary Drinking Water Regulations (table A-1)**. The EPA has proposed federal regulations for additional drinking water contaminants under the SWDA. Since the new regulations are only proposed, they are not shown in table A-1. The following paragraphs discuss common water quality problems found through out the study area.

The SDWA establishes **National Primary and Secondary Drinking Water Regulations**. The primary regulations specify enforceable maximum contaminant levels (MCL) and the secondary regulations specify maximum contaminant level goals (MCLG) which are judged to be requisite to protect the public welfare.

Dissolved solids and total dissolved solids (TDS) are terms generally associated with fresh water systems and represents the total amount of solids remaining when a water sample is evaporated to dryness. The principal inorganic anions dissolved in water include the carbonates, chlorides, sulfates, and nitrates (principally in ground water); the principal cations are sodium, potassium, calcium, and magnesium. Although **salinity** is an oceanographic term and not precisely equivalent to the TDS content (EPA, 1986) in this study; the terms TDS content and salinity are interchangeable. **Mineralized** and **mineralization** are additional terms used in this study to describe increases in the TDS content of ground water.

A general classification scheme of waters based on TDS (adapted from Drever, 1982) follows:

1. **Fresh waters** having less than about 1000 milligrams per liter (mg/L) are sufficient dilute to be **potable**.

2. **Brackish waters** (approximately 1,000 to 20,000 mg/L) are significantly less saline than seawater yet too saline to be potable.

3. **Saline waters** have salinities similar to or greater than that of seawater (35,000 mg/L TDS); **brine** is significantly more saline than seawater.

The SWDA establishes MCLG for TDS (500 mg/L), chloride (250 mg/L), and sulfate (250 mg/L) as shown in table A-1. Excess dissolved solids are objectionable in drinking water because of possible physiological effects, unpalatable mineral tastes, and higher costs because of corrosion or the necessity for additional treatment.

TABLE A-1

NATIONAL PRIMARY DRINKING WATER REGULATIONS

SUBSTANCE	**STANDARD** 1/
Arsenic	0.05 mg/l
Barium	1.0 mg/l
Benzene	0.005 mg/l
Beta particle and photon radioactivity	4 mrem (annual dose equivalent)
Cadmium	0.010 mg/l
Carbon Tetrachloride	0.005 mg/l
Chromium	0.05 mg/l
Coliform bacteria	< 1/100 ml
2,4-D	0.1 mg/l
para-Dichlorobenzene	0.075 mg/l
1,2-Dichloroethane	0.005 mg/l
1,1-Dichloroethylene	0.007 mg/l
Endrin	0.0002 mg/l
Fluoride	4 mg/l
Gross alpha particle activity	15 pCi/l
Lead	0.05 mg/l
Lindane	0.004 mg/l
Mercury	0.002 mg/l
Methoxychlor	0.1 mg/l
Nitrate (as N)	10 mg/l
Radium-226 + Radium-228	5 pCi/l
Selenium	0.01 mg/l
Silver	0.05 mg/l
Toxaphene	0.0005 mg/l
2,4,5-TP Silvex	0.01 mg/l
1,1,1-Trichloroethane	0.2 mg/l
Trichloroethylene	0.005 mg/l
Trihalomethanes (the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform)	0.10 mg/l
Turbidity	1 Tu (up to 5 Tu)
Corrosion Monitoring and Distribution System Compositon	
Sodium Monitoring and Reporting	

NATIONAL SECONDARY DRINKING WATER REGULATIONS

Chloride	250 mg/l
Color	15 color units
Copper	1 mg/l
Corrosivity	non-corrosive
Fluoride	2 mg/l
Foaming Agents	0.5 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
Odor	3 threshold odor number
pH	6.5 - 8.5
Sulfate	250 mg/l
TDS	500 mg/l
Zinc	5 mg/l

1/ Abbreviations: mg/l = milligram per liter
Tu = nephelometric turbidity units
mrem = millirem
pCi/l = picoCuries per liter

Any appreciable reduction in TDS levels must be accomplished by expensive water treatments like reverse osmosis, electrodialysis, or distillation.

Hardness is a term commonly used to evaluate certain properties of water and the property of hardness is difficult to define exactly (Hem, 1985). Water hardness is caused by the polyvalent metallic ions (principally calcium and magnesium) dissolved in water, commonly expressed as an equivalent concentration of calcium carbonate ($CaCO_3$). Other metals such as iron, strontium, and manganese contribute to hardness when significant concentrations are present. Increasing hardness reduces the cleansing action of soap and increases the tendency of scale deposits to form when water is heated. Hardness levels, which specific industrial uses can tolerate, are quite variable. Water hardness is also believed to be related to certain health problems. Although the exact process is unknown, the *National Academy of Science Summary Report* (1977) concludes that

> ...the preponderance of reported evidence reflects a consistent trend of statistically significant inverse correlation between the hardness of water and the incidence of cardiovascular diseases.

The OWRB (1984) states that when hardness exceeds 180 mg/L in household uses, treatment for its removal is generally desirable. The classification scheme of water by hardness content used for the NW Oklahoma Water Supply Study is presented in table A-2.

Table A-2.--Classification of water by hardness content (EPA, 1986)

Concentration (mg/L of $CaCO_3$)	Description
0 - 75	soft
75 - 150	moderately hard
150 - 300	hard
300 and up	very hard

Another water quality term often used is **pH** which is a measure of the hydrogen ion activity in a water sample. The MCLG for pH is shown in previous table A-1. The pH is an important factor in the chemical and biological systems of natural waters. The solubilities of metals (e.g., iron and manganese) and the toxicity of many compounds (e.g., HCN, H_2S) are affected by pH. The pH of most natural waters is controlled by reactions involving the carbonate system and is relatively easy to adjust during the water treatment process. Waters not adjusted to acceptable pH levels may be corrosive and adversely affect treatment processes.

Standard Water Treatment Description

EPA's definition of a standard water treatment process is:

1. Coagulation (less than about 50 mg/l alum, ferric sulfate, or copper as alkali or acid addition as necessary but without coagulant aids or activated carbon);

2. Sedimentation (6 hours or less);

3. Rapid sand filtration (3 gallons per square foot per minute or more); and

4. Disinfection with chlorine (without consideration to concentration or form of chlorine residual).

Predicting the need for iron and manganese reduction is difficult because of the number of variables involved. Additional data and analyses are needed to determine if additional treatment is needed.

Physical properties of water sometimes included in water quality analysis are color and turbidity. Highly colored water will interfere with the standard water treatment process (EPA, 1973).

Turbidity and total suspended solids (TSS) can interfere with the standard water treatment. Their effect is highly variable, and no standard has been established. If the turbidity cannot easily be removed by standard methods, the turbidity and TSS must be reduced to a suitable pretreatment method.

Taste and odor control is usually for aesthetic reasons, but these problems can also make the water completely undrinkable.

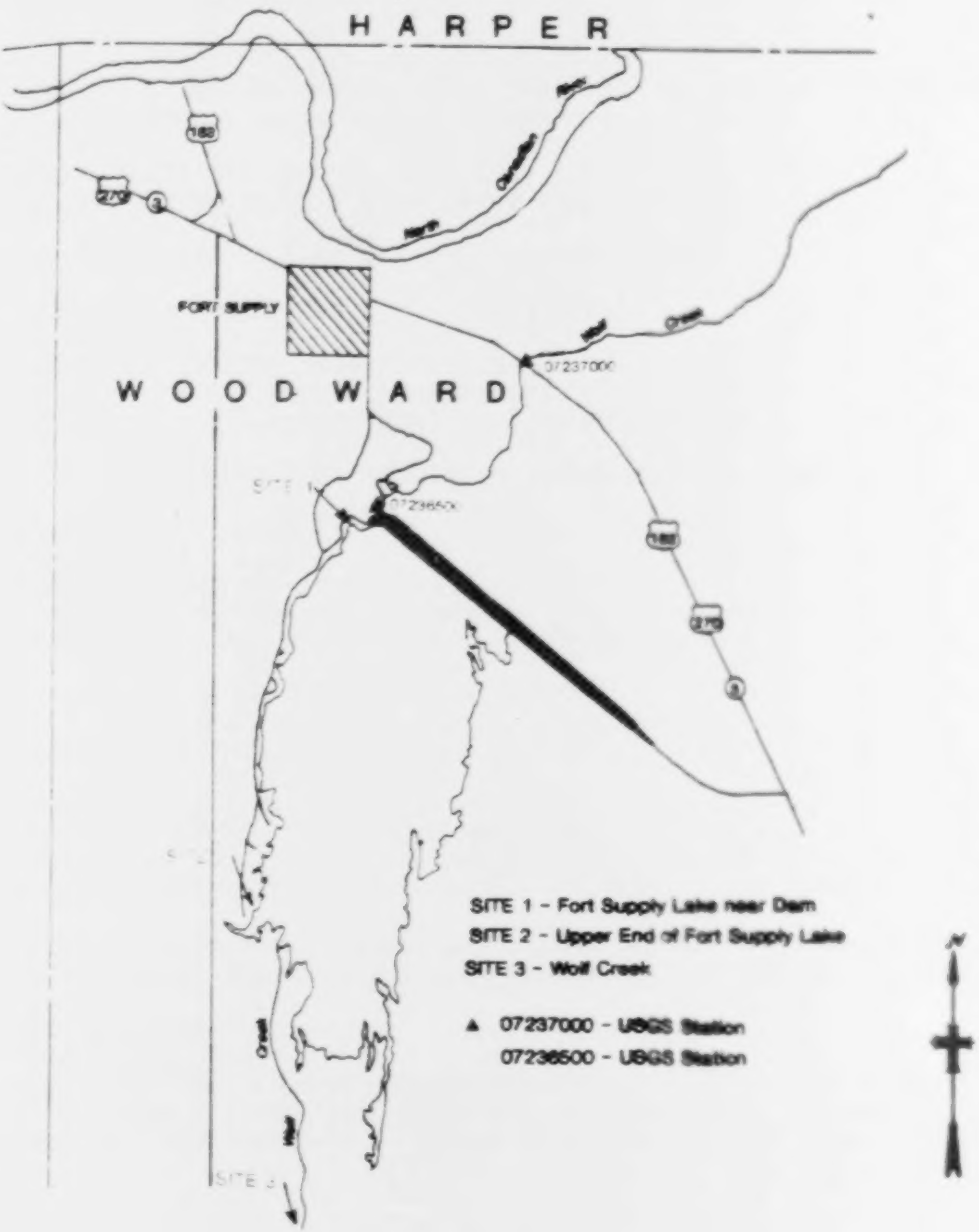

HARPER
North Canadian River
183
270
3
FORT SUPPLY
Wolf Creek
07237000
WOODWARD
SITE 1
07236500
183
270
3
SITE 2
Wolf Creek
SITE 3
SITE 1 - Fort Supply Lake near Dam
SITE 2 - Upper End of Fort Supply Lake
SITE 3 - Wolf Creek
▲ 07237000 - USGS Station
07236500 - USGS Station
N

Figure A-1. Water Quality Sampling Locations (11-14-89) - Fort Supply Lake, Oklahoma.

TABLE A-3
FIELD DATA

A. RESULTS OF WATER QUALITY DATA TAKEN AT FORT SUPPLY RESERVOIR NEAR WOODWARD, OKLAHOMA ON NOVEMBER 14, 1989:

RESERVOIR ELEVATION @ 8:00 AM - 2004.07
RESERVOIR CONTENT @ 8:00 AM - 13900 ACRE FEET

FORT SUPPLY RESERVOIR AT DAM NEAR OUTLET WORKS

1. TEMPERATURE (DEGREES C)......11.05
2. pH (SU)......8.79
3. DISSOLVED OXYGEN (MG/L)......10.95
4. SPECIFIC CONDUCTANCE (MICROMHOS/CM)......1004
5. REDUCTION / OXIDATION POTENTIAL (MILLIVOLTS)......106

FORT SUPPLY RESERVOIR AT UPPER END OF RESERVOIR

1. TEMPERATURE (DEGREES C)......11.90
2. pH (SU)......8.43
3. DISSOLVED OXYGEN (MG/L)......9.74
4. SPECIFIC CONDUCTANCE (MICROMHOS/CM)......1004
5. REDUCTION / OXIDATION POTENTIAL (MILLIVOLTS)......145

WOLF CREEK ABOVE FORT SUPPLY RESERVOIR

1. TEMPERATURE (DEGREES C)......11.45
2. pH (SU)......8.48
3. DISSOLVED OXYGEN (MG/L)......12.34
4. SPECIFIC CONDUCTANCE (MICROMHOS/CM)......993
5. REDUCTION / OXIDATION POTENTIAL (MILLIVOLTS)......121
6. ROUGHLY ESTIMATED FLOW (CUBIC FEET PER SECOND)..200 (LOW)

B. RESULTS OF WATER QUALITY DATA TAKEN ON THE CIMARRON RIVER SEVEN MILES NORTH OF FORGAN, OKLAHOMA ON NOVEMBER 14, 1989:

1. TEMPERATURE (DEGREES C)......16.98
2. DISSOLVED OXYGEN (MG/L)......9.64
3. SPECIFIC CONDUCTANCE (MICROMHOS/CM)......150
4. REDUCTION / OXIDATION POTENTIAL (MILLIVOLTS)......590
5. ROUGHLY ESTIMATED FLOW (CUBIC FEET PER SECOND)..100 (LOW)

Table A-4 - Laboratory Analyses

	Sample Location		
Parameter	Site 3 (mg/L)	Site 2 (mg/L)	Site 1 (mg/L)
Nitrogen, Ammonia as N	0.113	<0.100	0.113
NO_2 - NO_3 as N	0.60	0.50	<0.50
Ortho phosphorus as P	0.018	0.082	0.053
Total Phosphorus	0.069	0.086	0.114
Sodium, total	92	99	101
Calcium, total	87	76	65
Magnesium, total	20	22	21
Potassium, total	4.6	5.4	6.8
Chloride	134	150	155
Solids, total dissolved	616	666	588
Alkalinity, total	218	223	201.0
Arsenic, total	<0.060	<0.060	<0.060
Cadmium, total	0.006	<0.005	<0.005
Chromium, total	<0.010	<0.010	<0.010
Iron, total	0.432	1.885	1.226
Manganese, total	0.030	0.042	0.042
Mercury, total	<0.0005	<0.0005	<0.0005
Selenium, total	<0.070	<0.070	<0.070
Zinc, total	<0.005	0.007	0.007

Remark - Code Explanation
< less than detection limit

Site 1 - Fort Supply Reservoir near Dam
Site 2 - South end of Fort Supply Reservoir
Site 3 - Wolf Creek

Table A-5

OKLAHOMA CONSERVATION COMMISSION LAKE SAMPLING SUMMARY INFORMATION

FORT SUPPLY RESERVOIR

Lake Hydrostructure in Woodward County
Lake Centroid LAT/LONG: 036 33 14/099 52 24
Stream(s): Wolf Creek
Surface Acres: 1,880 Av. Depth: 7.7 ft.
Date of Impoundment : 1942 Dam Faces: NNW
WQMP Segment/Cluster: 720500-03
REACH FILE No.: 11100203(003/004)

Monitoring Information for Chlorophyll-a (Units in ppb)

	Winter	Spring	Summer	Autumn
1987	-----	-----	31.13	18.96
1988	14.16	5.82	14.96	12.17
1989	8.97	17.35	-----	-----
Seasonal Averages	11.5	11.5	23	15.5
		Overall Average		15.3
	Carlson Trophic State Index			57

Monitoring Information for Turbidity (Units in NTUs)

	Winter	Spring	Summer	Autumn
1987	-----	-----	53.5	36
1988	33	48	67	39
1989	28	37	-----	-----
Seasonal Averages	30.5	42.5	60.2	37.5
		Overall Average		42.6

Monitoring Information for Conductivity (Units in micromhos)

	Winter	Spring	Summer	Autumn
1987	-----	-----	-----	830
1988	870	880	750	900
1989	790	900	-----	-----
Seasonal Averages	830	890	750	865
		Overall Average		833.7

Table A-6

```
                 COMPENDIUM OF NATIONAL EUTROPHICATION SURVEY LAKES IN OKLAHOMA

NAME        - FORT SUPPLY RESERVOIR     (EUTROPHIC)
COUNTY      - WOODWARD
STORET NO.  - 4006              WORKING PAPER NO.  586, NTIS ACCESSION NO. PB-268 378/AB

I. MORPHOMETRY                                                                          RETENTION TIME
                 LAKE TYPE     DRAINAGE AREA    SURFACE AREA     MEAN DEPTH    TOTAL INFLOW    (YEARS)
                                  (SQ KM)          (SQ KM)        (METERS)        (CMS)          1.6
                 IMPOUNDMENT     3869.50           7.61            11.9           2.310

                                                                                                               MEDIAN
II. PHYSICAL AND CHEMICAL CHARACTERISTICS                          MEDIAN          MEDIAN          MEDIAN        TOTAL N(MG/L)
        MEDIAN               MEDIAN            MEAN SECCHI DISC     TOTAL P(MG/L)  ORTHO P(MG/L)   INORG N(MG/L)     0.690
   ALKALINITY(MG/L)   CONDUCTIVITY(UMHOS)          (METERS)           0.070           0.014           0.135
        184.                 197.                    0.4

III. BIOLOGICAL CHARACTERISTICS (LAKE)
     MEAN CHLOROPHYLL A    ALGAL ASSAY CONTROL YIELD    LIMITING NUTRIENT AT SAMPLING TIME
          (UG/L)               (MG/L--DRY WT)
           9.7                   **********             ( 3/29/74) N        ( 6/10/74) N        (10/24/74) N

                   SUMMARY OF PHYTOPLANKTON DATA                                          10/24/74
           3/29/74                                   6/10/74                                                 COUNT
                                   COUNT    GENERA                      COUNT   GENERA                        557
  GENERA                            3098    OOCYSTIS                      682   STEPHANODISCUS                381
  KIRCHNERIELLA                      634    CHLAMYDOMONAS                 243   ANACYSTIS(MICROCYSTIS)        352
  ANACYSTIS(MICROCYSTIS)             493    CHROOMONAS                    195   CHLAMYDOMONAS                 352
  OOCYSTIS                           422    STEPHANODISCUS                195   OOCYSTIS                      264
  OSCILLATORIA                       352    ANKISTRODESMUS                146   CHROOMONAS                    588
  CHROOMONAS                        1197    OTHER                         243   OTHER
  OTHER                                                                                                      2494
                                                                         1704   TOTAL
  TOTAL                             6196    TOTAL

IV. NUTRIENT LOADING CHARACTERISTICS(LAKE)
    A. INPUT                                                   POINT SOURCE              NON-POINT SOURCE      TOTAL LOADING
                  POINT SOURCE            POINT SOURCE         SEPTIC TANKS (KG/YR)          (KG/YR)               (KG/YR)
                  MUNICIPAL (KG/YR)       INDUSTRIAL (KG/YR)         5.                       2335.                 3320.
    PHOSPHORUS       980.                 **********                105.                     49440.                52475.
    NITROGEN        2930.                 **********
    B. OUTPUT
                    OUTLET(S)             PERCENT       LAKE SURFACE AREA LOADING RATE
                     (KG/YR)              RETENTION             (G/SQ M/YR)
    PHOSPHORUS        2670.                  20.                   0.44
    NITROGEN         60715.                 LOSS                   6.9

V. NON-POINT-SOURCE NUTRIENT EXPORT
   STREAM NAME                MEAN FLOW      DRAINAGE AREA      MEAN TOTAL P      MEAN TOTAL N      TOTAL P EXPORT     TOTAL N EXPORT
                                (CMS)           (SQ KM)            (MG/L)            (MG/L)        (KG/SQ KM/YR)      (KG/SQ KM/YR)
   WOLF CREEK                   2.120          3589.7              0.038             0.837               0.5               9.
   HOGGY CREEK                  0.090           138.6              0.063             1.583               2.*              32.*
   UNNAMED CREEK                0.020            23.6              0.060             1.704               1.               36.
   EIGHTMILE CREEK              0.020            33.9              0.082             1.473               1.               29.

VI. MEAN NUTRIENT CONCENTRATIONS IN UNGAGED STREAMS
   STREAM NAME                MEAN TOTAL P    MEAN TOTAL N
                                 (MG/L)          (MG/L)
   TURKEY CREEK                  0.077           1.736
   TWENTYMILE CREEK              0.092           1.071
```

ATTACHMENT B
ENGINEERING COST ESTIMATES

Table B-1.--Construction cost estimate. Fort Supply pipeline unit SHEET 1 OF 6

PROJECT - Northwest Oklahoma Water Supply Study	BY - Frank Spellmann
DIVISION -	DATE - 12/20/89
UNIT -	TYPE - Sub-feasibility
FEATURE - Fort Supply Unit	LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	FORT SUPPLY DAM MODIFICATION				
1	Mobilization	Lump sum	ls		1,000,000
	(1) Existing Spillway				
2	Concrete for weir	3,500	yd3	250.00	875,000
3	Reinforcement	260,000	lb	0.60	156,000
4	Cement	24,000	cwt	5.00	120,000
5	Dowel bars (1400 lbs)	Lump sum	ls	Lump sum	6,000
				Subtotal	1,157,000
	(2) Relocate road				
6	Clear face of dam	1,400	yd3	5.00	7,000
7	Clear road right-of-way	66,000	sy	1.00	66,000
8	Compacted embankment	49,000	yd3	10.00	490,000
9	Road base	7,800	yd3	30.00	234,000
10	Asphalt paving	2,500	yd3	110.00	275,000
11	Place gravel on slopes	1,400	yd3	30.00	42,000
12	Bridge (50' x 24')	1,800	sf	100.00	180,000
				Subtotal	1,294,000
	(3) Existing outlet works				
13	Remove existing footbridge	Lump sum	ls		1,200
14	Concrete	50	yd3	400.00	20,000
15	Reinforcement	7,800	lb	0.60	4,680
16	Cement	280	cwt	5.00	1,400
17	Safety railing	300	lf	30.00	9,000
18	Compacted embankment	2,700	yd3	10.00	27,000
19	Place riprap	40	yd3	15.00	600
20	Place bedding for riprap	100	yd3	10.00	1,000
				Subtotal	64,880

Table B-1.--Construction cost estimate, Fort Supply pipeline un SHEET 2 OF 6

PROJECT - Northwest Oklahoma Water Supply Study	BY - Frank Spellmann
DIVISION -	DATE - 12/20/89
UNIT -	TYPE - Sub-feasibility
FEATURE - Fort Supply Unit	LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	(4) RCC spillway				
21	Clear dam slopes	44,000	yd3	10.00	440,000
22	Clear dam top	13,000	yd2	2.00	26,000
23	Excavation, dam	330,000	yd3	3.00	990,000
24	Filter membrane	120,000	yd2	1.00	120,000
25	Gravel blanket	40,000	yd3	37.00	1,480,000
26	Roller compacted concrete	195,000	yd3	50.00	9,750,000
27	Pipe drains	87,000	lf	1.00	87,000
28	Compacted backfill	6,500	yd3	10.00	65,000
29	Place riprap	3,100	yd3	30.00	93,000
30	Place bedding for riprap	1,000	yd3	10.00	10,000
31	Waste fill at campground	320,000	yd3	1.50	480,000
				Subtotal	13,541,000
	(5) Mitigation				
32	Lands development	1,985	acre	350.00	694,750
	(6) Recreation				
33	Structures and improvements	Lump sum	ls		2,655,000
	(7) Allowance for unlisted items	5	pct		993,370
	Contract Cost				21,400,000
	Contingency	25	pct		5,400,000
	Field Cost				26,800,000
	Noncontract Cost	30	pct		8,200,000
	Construction Cost (Dam w/o Lands)				35,000,000
	(8) Lands				
34	Fee title surface - project lands	2,220	acre	310.00	688,200
35	Fee title surface - project lands	2,220	acre	275.00	610,500
36	Fee title surface - mitigation lands	1,950	acre	310.00	604,500
37	Fee title surface - mitigation lands	1,950	acre	275.00	536,250
38	Improvements	Lump sum	ls		375,000
39	Severance damages	Lump sum	ls		50,000
40	Uneconomic remnants	Lump sum	ls		60,000
41	Relocation assistance	Lump sum	ls		50,000
				Subtotal	2,974,450
42	Acquisition costs @ 20 percent				625,550
	Costs of Lands (Dam Modification)				3,600,000
	Construction Cost (Dam modification)				38,600,000

Table B-1.--Construction cost estimate, Fort Supply pipeline unit SHEET 3 OF 6

PROJECT - Northwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Fort Supply Unit

BY - Frank Spellmann
DATE - 12/20/89
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	PIPELINE SYSTEM				
43	Mobilization	Lump sum	ls		3.000.000
	(1) Pipe				
44	Pipe, 4 A 25	93	lf	7.99	700
45	Pipe, 4 A 100	44,400	lf	7.99	354,800
46	Pipe, 4 A 125	111,079	lf	7.99	887.500
47	Pipe, 4 A 200	200	lf	7.99	1,600
48	Pipe, 4 A 225	18,772	lf	7.99	150.000
49	Pipe, 4 A 275	8.542	lf	7.99	68.300
50	Pipe, 4 A 300	711	lf	7.99	5.700
51	Pipe, 4 A 350	10,400	lf	7.99	83.100
52	Pipe, 4 A 375	102.800	lf	7.99	821,400
53	Pipe, 4 A 425	1.402	lf	8.39	11.800
54	Pipe, 4 A 450	28,688	lf	8.39	240.700
55	Pipe, 4 A 475	4,200	lf	8.49	35.700
56	Pipe, 4 A 500	133.552	lf	8.49	1.133.900
57	Pipe, 4 A 550	2,400	lf	8.39	20.100
58	Pipe, 4 A 700	400	lf	8.69	3.500
59	Pipe, 4 A 725	4.372	lf	8.69	38.000
60	Pipe, 4 A 750	103.098	lf	8.99	926.900
61	Pipe, 6 A 25	1.908	lf	10.73	20.500
62	Pipe, 6 A 125	4.823	lf	10.73	51.800
63	Pipe, 6 A 200	35	lf	10.73	400
64	Pipe, 6 A 225	79,778	lf	10.73	856.000
65	Pipe, 6 A 275	8,158	lf	10.73	87.500
66	Pipe, 6 A 300	27,839	lf	10.73	298.700
67	Pipe, 6 A 350	2.577	lf	10.73	27.700
68	Pipe, 6 A 450	20,712	lf	11.63	240.900
69	Pipe, 6 A 725	3,730	lf	12.63	47.100
70	Pipe, 6 A 750	10,702	lf	13.63	145.900
71	Pipe, 8 A 100	13.965	lf	14.17	197.900
72	Pipe, 8 A 125	9.029	lf	14.17	127,900
73	Pipe, 8 A 200	65	lf	14.17	900
74	Pipe, 8 A 250	69.200	lf	14.17	980,600
75	Pipe, 8 A 350	38.023	lf	14.67	557,800
76	Pipe, 8 A 425	20.449	lf	16.17	330.700
77	Pipe, 10 A 50	1.300	lf	17.48	22.700
78	Pipe, 10 A 75	22,800	lf	17.48	398.500
79	Pipe, 10 A 100	2,135	lf	17.48	37.300
80	Pipe, 10 A 125	12,872	lf	17.48	225.000
81	Pipe, 10 A 175	9,053	lf	17.48	158,200
82	Pipe, 10 A 425	12.723	lf	20.48	260.600
83	Pipe, 10 A 725	1,400	lf	25.98	36,400

Table B-1.--Construction cost estimate. Fort Supply pipeline unit SHEET 4 OF 6

PROJECT - Northwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Fort Supply Unit

BY - Frank Spellmann
DATE - 12/20/89
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
84	Pipe. 12 A 150	12.471	lf	20.80	259.400
85	Pipe. 12 A 175	44.747	lf	20.80	930.700
86	Pipe. 12 A 225	50.000	lf	20.80	1.040.000
87	Pipe. 12 A 250	71.800	lf	20.80	1.493.400
88	Pipe. 12 A 375	72.800	lf	24.30	1.769.000
89	Pipe. 12 A 425	2.877	lf	25.30	72,800
90	Pipe. 12 A 475	5.000	lf	28.30	141.500
91	Pipe. 12 A 525	41.700	lf	29.30	1.221.800
92	Pipe. 12 A 575	96.008	lf	30.30	2.909.000
93	Pipe. 12 A 675	102.750	lf	33.30	3.421.600
94	Pipe. 15 A 150	8.329	lf	25.79	214.800
95	Pipe. 15 A 225	19.600	lf	27.79	544.700
96	Pipe. 15 A 275	10.500	lf	27.79	291.800
97	Pipe. 15 A 300	58.200	lf	30.79	1.792.000
98	Pipe. 15 A 375	36.750	lf	31.79	1.168.300
99	Pipe. 15 A 575	15.292	lf	42.79	654.300
100	Pipe. 15 A 575	69.300	lf	42.79	2.965.300
101	Pipe. 18 A 225	5.000	lf	34.31	171.600
102	Pipe. 21 A 250	8.000	lf	45.03	360.200
103	Pipe. 30 A 125	35.600	lf	71.19	2.534.400
104	Pipe. 36 A 75	6.900	lf	90.82	626.700
105	Pipe. 36 A 150	27.300	lf	93.82	2.561.300
106	Pipe. 36 A 200	2.550	lf	97.82	249.400
107	Pipe. 39 A 250	5.250	lf	110.67	581.000
					37.870.000
	(2) Pumping plant PP-1				
108	Pumps and prime movers	Lump sum	ls	76,000	76,000
109	Structures and Improvements	Lump sum	ls	783,000	783,000
110	Accessory electrical equipment	Lump sum	ls	49,000	49,000
111	Miscellaneous equipment	Lump sum	ls	16,000	16,000
112	Substation	Lump sum	ls	70,000	70,000
113	Manifolds and valves	Lump sum	ls	57,000	57,000
114	Standby unit	Lump sum	ls	38,000	38,000
115	Transmission lines	Lump sum	ls	117,000	117,000
				Subtotal	1.206,000

Table B-1.--Construction cost estimate. Fort Supply pipeline un t SHEET 5 OF 6

PROJECT - Northwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Fort Supply Unit

BY - Frank Spellmann
DATE - 12/20/89
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	(3) Pumping plant PP-2				
116	Pumps and prime movers	Lump sum	ls	97,000	97,000
117	Structures and Improvements	Lump sum	ls	220,000	220,000
118	Accessory electrical equipment	Lump sum	ls	112,000	112,000
119	Miscellaneous equipment	Lump sum	ls	20,000	20,000
120	Substation	Lump sum	ls	91,000	91,000
121	Manifolds and valves	Lump sum	ls	145,000	145,000
122	Standby unit	Lump sum	ls	48,000	48,000
123	Transmission lines	Lump sum	ls	125,000	125,000
				Subtotal	858,000
	(4) Pumping plant PP-3				
124	Pumps and prime movers	Lump sum	ls	13,000	13,000
125	Structures and Improvements	Lump sum	ls	25,000	25,000
126	Accessory electrical equipment	Lump sum	ls	42,000	42,000
127	Miscellaneous equipment	Lump sum	ls	6,000	6,000
128	Substation	Lump sum	ls	68,000	68,000
129	Manifolds and valves	Lump sum	ls	20,000	20,000
130	Standby unit	Lump sum	ls	7,000	7,000
131	Transmission lines	Lump sum	ls	20,000	20,000
				Subtotal	201,000
	(5) Pumping plant PP-4				
132	Pumps and prime movers	Lump sum	ls	3,000	3,000
133	Structures and Improvements	Lump sum	ls	4,000	4,000
134	Accessory electrical equipment	Lump sum	ls	18,000	18,000
135	Miscellaneous equipment	Lump sum	ls	4,000	4,000
136	Substation	Lump sum	ls	53,000	53,000
137	Manifolds and valves	Lump sum	ls	5,000	5,000
138	Standby unit	Lump sum	ls	2,000	2,000
139	Transmission lines	Lump sum	ls	10,000	10,000
				Subtotal	99,000
	Total Pumping Plants				2,364,000

Table B-1.--Construction cost estimate. Fort Suppiy pipeline unit SHEET 6 OF 6

PROJECT - Northwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Fort Supply Unit

BY - Frank Spellmann
DATE - 12/20/89
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	(6) Other structures				
140	Crossings, roadway and railway (438)	Lump sum	ls	2.510.000	2.510.000
141	Crossings, minor streams	55	ea	20.000	1.100.000
142	Crossings, river	8	ea	50.000	400.000
143	Regulating Tank 1	Lump sum	ls	278.000	278.000
144	Regulating Tank 2	Lump sum	ls	232.000	232.000
145	Regulating Tank 3	Lump sum	ls	93.000	93.000
				Subtotal	4.513.000
146	(7) Allowance for unlisted items	10	pct		5.153.000
	Contract Cost				53.000.000
	Contingency	20	pct		10,000,000
	Field Cost				63,000,000
	Noncontract Cost	30	pct		19,000,000
	Construction Cost Pipeline w/o Lands				82.000.000
	(8) Lands				
147	Pipeline Rights-of-Way	332	mile	9.600	3.187.200
148	Appurtenances & Access ROW (5 %)				112.800
				Subtotal	3.300.000
149	Acquisition costs @ 20 percent				700.000
	Cost of Lands (Pipeline)				4.000.000
150	Archeology @ 0.5 %				400.000
	Construction Cost (Pipeline System)				86.400.000
	Construction Cost (w/o Treatment)				125.000.000
	Treatment Plant (Total Cost)				15,000,000
	Construction Cost (with Treatment)				140,000,000

Table B-2.--Construction cost estimate. Forgan pipeline unit SHEET 1 OF 7

PROJECT - Nothwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Forgan Unit

BY - Tom Rawlings
DATE - 6/11/90
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	FORGAN DAM				
1	Mobilization	Lump sum	ls	ls	3.100.000
	(1) Dam structure				
2	Diversion and care of water	Lump sum	ls	ls	500.000
3	Unwatering foundation	Lump sum	ls	ls	200.000
4	Stripping dam area	600.000	yd3	1.50	900.000
5	Excavation, common for cutoff trench	360.000	yd3	2.50	900.000
6	Slurry trench	480,000	ft2	6.00	2.880.000
7	Excavation, impervious	1.800.000	yd3	2.00	3,600.000
8	Excavation, semipervious	3.600.000	yd3	3.75	13.500.000
9	Earthfill in dam, impervious	1.800,000	yd3	1.25	2.250,000
10	Earthfill in dam, semipervious	3,700,000	yd3	1.00	3,700.000
11	Furn/place sand/gravel chimney drain	340,000	yd3	15.00	5.100,000
12	Furn/place toe drain	7.900	lf	25.00	197.500
13	Furn/place soil-cement upstream face	83,000	yd3	25.00	2,075.000
14	Furn/handle cement for soil-cement	12,000	ton	100.00	1.200.000
15	Furn/install dam instrumentation	Lump sum	ls	ls	100.000
16	20' Wide asphalt dam & access roads	7.500	lf	50.00	375.000
17	Clearing and grubbing reservoir area	Lump sum	ls	ls	200.000
18	Seeding on embankment	55	ac	800.00	44.000
				Subtotal	37.721.500
	(2) Service spillway				
19	Excavations for channels	180.000	yd3	2.00	360.000
20	Excavation for structure	80.000	yd3	3.00	240.000
21	Compacted backfill	23.000	yd3	6.00	138.000
22	Concrete Backfill concrete	6,300	yd3	100.00	630.000
23	Concrete in inlet walls, crest, crest structure walls, and piers	12,300	yd3	250.00	3.075.000
24	Concrete in spillway chute	4,800	yd3	250.00	1.200.000
25	Concrete in stilling basin	5.800	yd3	250.00	1.450.000
26	Furn/hand cementatious material	6.600	ton	100.00	660,000
27	Furn/hand reinforcement	2.800.000	lb	0.50	1.400.000
28	Furn/inst radial gates	390.000	lb	3.50	1.365.000
29	Furnish stoplogs	Lump sum	ls	ls	350.000
30	Riprap	1.200	yd3	30.00	36.000
31	Bedding for riprap	600	yd3	10.00	6.000
				Subtotal	10.910.000

Table B-2.--Construction cost estimate, Forgan pipeline unit

SHEET 2 OF 7

PROJECT - Nothwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Forgan Unit

BY - Tom Rawlings
DATE - 6/11/90
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	(3) Outlet works				
32	Excavation, common	20,000	yd3	3.00	60,000
33	Special compaction	2,500	yd3	10.00	25,000
34	Backfill	15,000	yd3	3.00	45,000
35	Concrete in intake	180	yd3	300.00	54,000
36	Concrete, Upstream conduit & collars	430	yd3	250.00	107,500
37	Concrete, downstream conduit & pipe	1,100	yd3	250.00	275,000
38	Concrete, stilling basin and chute	640	yd3	250.00	160,000
39	Concrete, control structure	440	yd3	300.00	132,000
40	Concrete, gate chamber	430	yd3	300.00	129,000
41	concrete, second stage	160	yd3	200.00	32,000
42	Furnishing/handling cement	950	ton	100.00	95,000
43	Furnishing/placing reinforcement	510,000	lb	0.50	255,000
44	Trashrack	9,400	lb	2.00	18,800
45	Bulkhead gate and seat	6,600	lb	3.50	23,100
46	54" Steel conduit liner	72,000	lb	2.50	180,000
47	54" Steel pipe	54,000	lb	2.00	108,000
48	2 - 48 inch x 48 inch slide gates	27,000	lb	3.50	94,500
49	Hydraulic control system	3,500	lb	8.00	28,000
50	Steel transitions	26,000	lb	3.50	91,000
51	Gate chamber ventilation	24,000	lb	2.50	60,000
52	Channel excavation	6,000	yd3	3.00	18,000
					1,990,900
	(4) Emergency spillway				
53	Excavation	100,000	yd3	3.00	300,000
54	Furn/place filter membrane	62,000	yd2	1.00	62,000
55	Furn/place gravel blanket	21,000	yd3	37.00	777,000
56	Furn/place roller compacted concrete	166,000	yd3	50.00	8,300,000
57	Furn/place pipe drains	50,000	lf	1.00	50,000
58	Furn/place riprap	3,700	yd3	30.00	111,000
59	Furn/place bedding for riprap	1,900	yd3	10.00	19,000
				Subtotal	9,619,000

Table B-2.--Construction cost estimate. Forgan pipeline unit SHEET 3 OF 7

PROJECT - Nothwest Oklahoma Water Supply Study	BY - Tom Rawlings
DIVISION -	DATE - 6/11/90
UNIT -	TYPE - Sub-feasibility
FEATURE - Forgan Unit	LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	(5) Mitigation				
60	Lands development	Lump sum	ls	ls	585,000
	(6) Recreation				
61	Structures and improvements	Lump sum	ls	ls	2,000,000
62	(7) Allowance for unlisted items	12	pct		7,873,600
	Contract Cost				73,800,000
	Contingency	25	pct		18,500,000
	Feild Cost				92,300,000
	...				
	Noncontract Cost	30	pct		27,700,000
	Construction Cost				120,000,000
	(8) Lands				
63	Fee title surface - project area	11,500	acre	135.00	1,552,500
64	Fee title mineral - project area	11,500	acre	175.00	2,012,500
65	Fee title surface - mitigation lands	1,300	acre	135.00	175,500
66	Fee title mineral - mitigation lands	1,300	acre	175.00	227,500
65	Improvements	Lump sum	ls	ls	80,000
66	Producing gas properties	Lump sum	ls	ls	1,800,000
67	Producing oil properties	Lump sum	ls	ls	500,000
68	Relocation assistance	Lump sum	ls	ls	20,000
					6,368,000
69	Acquisition costs @ 15 percent				932,000
	Costs of Lands for Forgan Dam				7,300,000
	Construction Cost for Forgan Dam				127,300,000

Table B-2.--Construction cost estimate, Forgan pipeline unit SHEET 4 OF 7

PROJECT - Nothwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Forgan Unit

BY - Tom Rawlings
DATE - 6/11/90
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	PIPELINE SYSTEM				
70	Mobilization	Lump sum	ls		3.000.000
	1) Pipe				
71	Pipe, 4 A 250	97.100	lf	7.99	775.800
72	Pipe, 4 A 350	84.100	lf	7.99	672.000
73	Pipe, 4 A 375	41.000	lf	7.99	327.600
74	Pipe, 4 A 400	18.100	lf	7.99	144.600
75	Pipe, 4 A 450	43.000	lf	8.39	360.800
76	Pipe, 6 A 325	28.592	lf	10.73	306.800
77	Pipe, 6 A 350	13.047	lf	10.73	140,000
78	Pipe, 8 A 200	38.595	lf	14.17	546.900
79	Pipe, 8 A 325	5,908	lf	14.67	86.700
80	Pipe, 8 A 350	15.453	lf	14.67	226.700
81	Pipe, 10 A 200	13.005	lf	17.48	227.300
82	Pipe, 10 A 400	65.199	lf	20.48	1.335.300
83	Pipe, 12 A 300	21.610	lf	21.80	471.100
84	Pipe, 12 A 300	38.367	lf	21.80	836,400
85	Pipe, 12 A 450	30.289	lf	28.30	857.200
86	Pipe, 15 A 250	78.300	lf	27.79	2.176.000
87	Pipe, 15 A 300	152.923	lf	30.79	4,708,500
88	Pipe, 15 A 425	153	lf	33.79	5.200
89	Pipe, 15 A 450	5.311	lf	36.79	195.400
90	Pipe, 18 A 425	54.747	lf	44.31	2.425.800
91	Pipe, 33 A 150	39.899	lf	81.99	3.271.300
92	Pipe, 33 A 225	55.000	lf	85.99	4.729.500
93	Pipe, 33 A 300	41.799	lf	102.99	4.304.900
94	Pipe, 33 A 400	36.921	lf	107.99	3,987.100
95	Pipe, 33 A 475	18.300	lf	110.99	2.031.100
96	Pipe, 36 A 300	7.100	lf	116.82	829.400
97	Pipe, 36 A 400	27.728	lf	121.82	3.377.800
98	Pipe, 39 A 200	91.500	lf	110.67	10.126.300
99	Pipe, 39 A 400	26.151	lf	137.67	3.600.200
100	Pipe, 39 A 475	6.800	lf	142.67	970.200
				Subtotal	54.053.900

Table B-2.--Construction cost estimate, Forgan pipeline unit SHEET 5 OF 6

PROJECT - Nothwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Forgan Unit

BY - Tom Rawlings
DATE - 6/11/90
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	(2) Pumping plant PP-1				
101	Pumps and prime movers	Lump sum	ls	304,000	304,000
102	Structures and Improvements	Lump sum	ls	466,000	466,000
103	Accessory electrical equipment	Lump sum	ls	292,000	292,000
104	Miscellaneous equipment	Lump sum	ls	31,000	31,000
105	Substation	Lump sum	ls	169,000	169,000
106	Manifolds and valves	Lump sum	ls	304,000	304,000
107	Air chamber	Lump sum	ls	140,000	140,000
108	Transmission lines	Lump sum	ls	300,000	300,000
				Subtotal	2,006,000
	(3) Pumping plant PP-2				
109	Pumps and prime movers	Lump sum	ls	285,000	285,000
110	Structures and Improvements	Lump sum	ls	439,000	439,000
111	Accessory electrical equipment	Lump sum	ls	280,000	280,000
112	Miscellaneous equipment	Lump sum	ls	29,000	29,000
113	Substation	Lump sum	ls	165,000	165,000
114	Manifolds and valves	Lump sum	ls	285,000	285,000
115	Air chamber	Lump sum	ls	130,000	130,000
116	Storage facility	Lump sum	ls	100,000	100,000
				Subtotal	1,713,000
	(4) Pumping plant PP-3				
117	Pumps and prime movers	Lump sum	ls	28,000	28,000
118	Structures and Improvements	Lump sum	ls	37,000	37,000
119	Accessory electrical equipment	Lump sum	ls	62,000	62,000
120	Miscellaneous equipment	Lump sum	ls	7,000	7,000
121	Substation	Lump sum	ls	91,000	91,000
122	Manifolds and valves	Lump sum	ls	28,000	28,000
123	Air chamber	Lump sum	ls	10,000	10,000
124	Storage facility	Lump sum	ls	100,000	100,000
				Subtotal	363,000

Table B-2.--Construction cost estimate, Forgan pipeline unit SHEET 6 OF 7

PROJECT - Nothwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Forgan Unit

BY - Tom Rawlings
DATE - 6/11/90
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
	(5) Pumping plant PP-4				
125	Pumps and prime movers	Lump sum	ls	20,000	20,000
126	Structures and Improvements	Lump sum	ls	25,000	25,000
127	Accessory electrical equipment	Lump sum	ls	50,000	50,000
128	Miscellaneous equipment	Lump sum	ls	6,000	6,000
129	Substation	Lump sum	ls	84,000	84,000
130	Manifolds and valves	Lump sum	ls	20,000	20,000
131	Air chamber	Lump sum	ls	10,000	10,000
132	Storage facility	Lump sum	ls	100,000	100,000
				Subtotal	315,000
	(6) Pumping plant PP-5				
133	Pumps and prime movers	Lump sum	ls	20,000	20,000
134	Structures and Improvements	Lump sum	ls	25,000	25,000
135	Accessory electrical equipment	Lump sum	ls	50,000	50,000
136	Miscellaneous equipment	Lump sum	ls	6,000	6,000
137	Substation	Lump sum	ls	84,000	84,000
138	Manifolds and valves	Lump sum	ls	20,000	20,000
139	Air chamber	Lump sum	ls	10,000	10,000
140	Storage facility	Lump sum	ls	100,000	100,000
				Subtotal	315,000
	Total Pumping Plants				4,712,000
	(6) Other structures				
141	Crossings, roadway and railway (438)	Lump sum	ls	1,749,900	1,749,900
142	Crossings, minor streams	31	ea	20,000	620,000
143	Crossings, river	4	ea	50,000	200,000
				Subtotal	2,569,900

Table B-2.--Construction cost estimate. Forgan pipeline unit SHEET 7 OF 7

PROJECT - Nothwest Oklahoma Water Supply Study
DIVISION -
UNIT -
FEATURE - Forgan Unit

BY - Tom Rawlings
DATE - 6/11/90
TYPE - Sub-feasibility
LEVEL - Jan 90

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT
144	(7) Allowance for unlisted items	10	pct		6,464,200
	Contract Cost				70,800,000
	Contingency	20	pct		14,200,000
	Field Cost				85,000,000
	Noncontract Cost	30	pct		26,000,000
	Construction Cost Pipeline w/o Lands				111,000,000
	(8) Lands				
145	Pipeline Rights-of-Way	226	mile	7,200	1,627,200
146	Appurtenances & Access ROW (5 %)				72,800
				Subtotal	1,700,000
147	Acquisition costs @ 20 percent				300,000
	Cost of Lands (Pipeline)				2,000,000
	Construction Cost (Pipeline System)				113,000,000
148	Archeology @ 0.5 %				1,200,000
	Construction Cost (w/o Treatment)				241,500,000
	TREATMENT FACILITIES				
149	Conventional treatment process	Lump sum	ls		22,000,000
150	Reverse osmosis process	Lump sum	ls		36,000,000
151	Land disposal for brine	Lump sum	ls		42,000,000
	Treatment Plant (Total Cost)				100,000,000
	Construction Cost (with Treatment)				341,500,000

ATTACHMENT C
RECREATION DEVELOPMENT COSTS

Table C-1.-- Ft. Supply Estimated Cost for Relocation/Replacement of Recreation Related Facilities

Replace the following:

Facility	Cost/Unit	Total Cost
West Side		
Replace 4 single lane ramps with 2 24 ft x 48 ft double lane boat launch ramps	$ 5,500/ea	$ 22,000
Replace 3 vehicle parking lots with 2 120 ft x 180 ft asphalt 24 vehicle and trailer parking areas	48,000/ea	96,000
Replace 1 swimming beach area	10,000	10,000
Replace 4 miles of asphalt surfaced road	462,000/ea	1,848,000
Replace entrance station--includes water, electricity and telephone	10,000	10,000
Replace picnic sites--includes water, electricity, barbecue grill, campfire ring, table, shelter, and pad plus graveled parking	1,000/ea	50,000
Replace group picnic shelter facility--includes water, electricity, barbecue grill and tables	15,000	15,000
Replace 161 campsites--includes water, grill, electricity, shelter, and table	1,000/ea	161,000
Replace existing guardrails and barriers	5,000	5,000
Replace underground electrical service to picnic and campground vicinity	15,000	15,000
Replace underground water distribution system	26,000	26,000
East Side		
Replace existing ramps with 2 double lane concrete ramps	$ 5,500/ea	$ 22,000
Replace 2 parking areas with 2 120 ft x 180 ft gravel covered 24 unit vehicle and boat trailer parking areas	30,000/ea	60,000
Replace existing double restroom facility	50,000/ea	50,000
Replace 3 miles of roads with graveled roads	25,000/mi	50,000
Replace two [illegible] shelter houses	15,000/ea	30,000

Relocate and/or Construct/Install the Following:

Facility	Cost/Unit	Total Cost
West Side		
Relocate existing double restroom	$ 50,000	$ 50,000
Relocate existing single toilets	250/ea	5,000
Relocate existing dock facility	500	500
Relocate six security lights	1,000/ea	6,000
Relocate overhead electric facilities	3,000	3,000
Relocate guardrails and/or barriers	2,000/.25 mi	12,000
Relocate existing signs	2,000	2,000
Relocate 2 sets of playground equipment	1,000/set	2,000
Procure and install necessary signs	2,000	2,000
Perform necessary landscaping and planting	25,000	25,000
East Side		
Prepare new swimming beach (150 feet)	10,000	10,000
Procure and install playground equipment at beach area	5,000/set	5,000
Relocate trash stations	100/site	2,000
Procure and install necessary signs	2,000	2,000
Perform necessary landscaping and planting	10,000	10,000
Recreation land replacement - 2,460 acres	250/acre	615,000
Total		$3,221,500

Table C-2.--Proposed recreation facilities - Forgan Reservoir

---

Boat ramps - two double-lane ramps, one on each side of the reservoir.

Parking areas - adequate parking for boat trailers, beach users, campers, and trail users.

Campgrounds - two 80-unit campgrounds, one on each side of reservoir. Fifty percent of each campground suitable for motor homes.

Sanitary/shower facilities (associated with campgrounds).

Beaches - two beaches, one on each side of reservoir.

Beach change houses - two, one on each side of reservoir.

Public vehicle access roads (roads inside the developed recreation area should be paved; access roads should be graveled.

Trail - one loop trail that goes completely around the reservoir. This trail should be a path that is wide enough to accommodate only nonmotorized use, i.e., foot, horse, bicycle.

Trash/dump stations - two, one on each side of reservoir.

Shelters - must be provided to allow visitors a chance to escape from the sun. Sites would be located in campgrounds and near beaches.

Landscaping - trees, shrubs and other vegetation should be planted around the entire reservoir as well as recreation areas.

Security lights - (as needed).

BBQ grills, picnic tables.

Water/electricity hook-ups - (may be phased in later).

Maintenance building/office/yard.

Trash removal/disposal.

Wood fence - built around recreation areas to exclude live-stock. Should consider fencing land around entire reservoir; livestock allowed to mix with recreationists will create problems for all parties and will cause water quality problems.

Signs - for direction, identification, regulatory, information, etc.

Drinking water - two sites, one on each side of reservoir (wells or other supply).

Swimming area buoys.

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
POST OFFICE BOX 61
TULSA, OKLAHOMA 74121-0061

REPLY TO
ATTENTION OF:

February 12, 1990

FEB 23 '90

REPLY DATE

DATE	INITIALS	CODE
2-23	VL	5540

Information copy to:

Classification

Control No.

Folder I.D.

0000072 FEB 23 90

Operations
Project Operations

Mr. Dan Rubenthaler
P.O. Box 25007
Denver, CO 80225-0007

Dear Mr. Rubenthaler:

This letter concerns your study to raise Fort Supply Lake Conservation Pool from elevation 2004.0 to 2015.0 feet National Geodetic Vertical Datum(NGVD) for water supply for a three-county area in northwest Oklahoma.

Vernon Lovejoy of your office requested a letter from us regarding the clearing of standing timber at Fort Supply Lake, if the conservation pool is increased as stated above.

Overall, we generally agree that leaving the standing timber would be very beneficial to the fisheries program at the lake and would also be a tremendous plus as waterfowl wintering habitat in the lake area. However, the following item needs to be addressed:

As the lake lies generally southeast to northwest with the dam at the north end, the prevailing southerly summer winds will deposit all woody debris toward the north end of the lake where it will be a major problem in our recreation areas, beaches, gate tower area, and along the dam. This will occur during our highest visitation period and when most water releases are made.

The following is recommended:

a. Trasn racks should be installed on existing gates and any proposed additional gates.

b. All existing timber between elevations 2004.0 and 2015.0 feet NGVD that would be located adjacent to the relocated recreation areas, swim beaches, and boat ramps should be removed.

c. The lake should be filled in stages, 2 to 4 feet per year, until the conservation pool elevation is reached in order to improve the lake fishery.

d. Clearing of boat lanes in areas to be inundated at the south end should be considered for fisherman and hunter access, though this may not be feasible because much of the area to be flooded is wetlands. If the boat lanes are cleared, they should be marked for safety reasons, because they will not be defined as the timber ages and falls.

In addition, since this proposed project will inundate all the prime wetland areas on Fort Supply Lake, it is recommended that wildlife mitigation be centered around acquiring wetlands, oxbows, and sloughs from our existing south boundary to west of the bridge on Wolf Creek, just north of Fargo, Oklahoma. There are some prime waterfowl areas located along this stretch of Wolf Creek with much potential for development. As this would be public hunting land, consideration should be given to making this corridor at least 1/2 to 3/4 miles wide and to providing adequate access for hunters and fishermen.

After review of the recreation/resource portion of your study in our District Office, the following comments are also made:

a. As all of the area licensed to the Oklahoma Department of Wildlife Conservation will be inundated, it is felt that the effects of this proposal on wildlife have not been adequately addressed.

b. The standing timber that is cut should be piled in an orderly manner in strategic locations in the lake, and cabled down and buoyed in order to provide additional fishing opportunities to the public once the new conservation pool elevation is reached.

c. It appears that the estimates for relocating and constructing new recreational facilities are low, if it is to be done by contract. It should also be mentioned that construction of these recreation facilities will have to be cost-shared.

Due to the extensive effects of the proposed project on fish and wildlife, recreation, and licensed areas of the project, it is requested that our Operations and Real Estate Divisions be included in the meeting you intend to hold with our Planning Division for a briefing on this study.

Please contact Mrs. Susan Couch of my staff at 918-581-7356, if you have any questions concerning our above comments.

Sincerely,

John P. Clark, P.E.
Chief, Operations Division

March 06, 1990

Mr. Dan Rubenthaler
Bureau of Reclamation
P.O. Box 25007
Denver, CO 80225

Dan:

I was contacted by an associate of yours, Mr. Vernen Lovejoy, concerning a study on Northwestern Oklahoma water supply. Mr. Lovejoy commented that the proposal was to raise the water level to a height of eleven feet at the dam at U.S.A.C.E. reservoir Fort Supply. Mr. Lovejoy said that it would be of benefit to this study if I made comments concerning potential impact to the fisheries resources.

The first benefit will be the flooding of an additional 2,000 acres in the upper area of the lake. The flooding of this area will provide a large amount of habitat which will benefit structure loving fish such as largemouth bass, bluegill sunfish and white crappie. If, flooded the area would benefit the fisheries resources more if the timber and brush are left intact. If the brush is too dense to allow recreational use of the area boat lanes may be cut, but the brush should be wind-rowed and anchored in another area.

The second benefit will come from the additional depth in the dam area. During winter months, game fish concentrate in the discharge area of Ft. Supply searching for more comfortable temperatures. These fish experience heavy angling mortality at this time. By increasing the water depth these fish will dispense more and not be harvested in such high numbers.

If you need any additional information please contact me.

Sincerely,

John Stahl

John Stahl/Regional Supervisor
Rt. 1. Box 67
Byron, OK 73723
PH (405)474-2663

JS/rs

John Stahl
Byron State Fish Hatchery
Department of Wildlife Conservation
Rt. 1. Box 67
Byron, Oklahoma 73723

ATTACHMENT B
ALTERNATIVE COSTS — FORGAN UNIT

ATTACHMENT D

Alternative Costs for Forgan Unit

The estimated average annual cost attributable to municipal and industrial water would be $6.63 per thousand gallons without reverse osmosis and without evaporation ponds.

The estimated average annual cost attributable to municipal and industrial water when costs for Lateral 5 and deliveries to Keyes and Boise City are deleted would be $12.20 per thousand gallons.

The summary of the above costs is shown in the following tabulation.

Forgan Dam and Reservoir summary of repayment costs[1]	Forgan Unit without reverse osmosis & without evaporation ponds	Forgan Unit without lateral 5 & without deliveries to Keyes and Boise City;
Yield (annual acre-feet)	24,100	24,100
Average annual delivery (acre-feet)	17,000	11,615
Construction cost	258,500,000	316,800,000
Less recreational costs	3,640,000	3,640,000
Assignable construction cost	254,860,000	313,160,000
Interest during construction	55,437,000	68,119,000
Total investment cost	310,297,000	381,279,000
Annual investment cost	31,522,000	38,733,000
Annual OMR&E	5,210,000	7,449,000
Total average annual cost	36,732,000	46,182,000
Annual cost per acre-foot	2,161.00	3976.00
Annual cost per 1,000 gallons for M&I deliveries	6.63	12.20

---

[1] Based on a 50-year repayment period and a repayment rate of 10.075 percent.

ATTACHMENT E
FWS PLANNING AID REPORTS

Final
Planning Aid Report
for
Northwest Oklahoma Water Supply Study - Forgan Dam and Reservoir, Kansas

Prepared by
U.S. Department of the Interior
Fish and Wildlife Service
Kansas State Office
Manhattan, Kansas

and

Oklahoma State Office
Tulsa, Oklahoma

Prepared for
U.S. Department of the Interior
Bureau of Reclamation
Billings, Montana

September, 1990

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Introduction

This Planning Aid Report (Report) for the Northwest Oklahoma Water Supply Study is provided pursuant to our Fiscal Year 1990 Scope-of-Work Agreement. It addresses the proposed Forgan Dam and Reservoir project located on the Cimarron River in Meade County, Kansas and water distribution pipelines in Oklahoma. This Report provides technical assistance only and does not constitute the report of the Secretary of Interior on the study within the meaning of Section 2(b) of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.).

Information contained in this report was obtained from aerial photos, maps, U.S. Fish and Wildlife Service (Service) field investigations, reports, and files, and from reports and files of, and consultation with, the staff of the Kansas Department of Wildlife and Parks, U.S. Soil Conservation Service, U.S. Geological Survey, U.S. Bureau of Reclamation (Bureau), and the Kansas Water Office. Projections of downstream effects of Forgan Reservoir were developed using the Draft Revised Reservoir Operations Study for Proposed Forgan Reservoir Site- Northwest Oklahoma Water Supply Study (June 25, 1990), previous studies on western Oklahoma river systems, and river corridor measurements taken from topographic maps.

The purpose of the Northwest Oklahoma Water Supply Study is to evaluate existing and future water demands, supply, and treatment needs in northwest Oklahoma. This Report provides information on fish and wildlife resources, endangered and threatened species, and important fish and wildlife habitats of the project area. It also provides a preliminary evaluation, mitigation costs, and recommendations associated with the proposed Forgan Dam and Reservoir project.

Description of the Study Area

The project area lies within the High Plains section of the Great Plains physiographic province (Self 1978). Soils on the floodplain of the Cimarron River are primarily the Kanza series consisting of deep, poorly drained, nearly level soils overlaying sand (USDA 1977). The climate is described as semiarid because the average evapotranspiration is considerably higher than the average precipitation reached each year. Average annual lake evaporation is approximately 63 inches (Hjelmfelt and Cassidy 1975); whereas, precipitation in Meade County, Kansas averages about 21 inches annually.

Within the project area the most prominent topographic feature is the Cimarron River itself and its associated floodplain. The river has a total drainage area of 19,690 square miles and a total length of 692 miles. Four hundred and sixty miles of the river lie within Oklahoma and about 150 miles lie within Kansas.

Within the river corridor the Cimarron River has a broad, braided, uniformly sandy channel averaging about 150 feet wide. Cut banks give way to subirrigated wetlands, some of which extend over 1/4 mile from the river banks. The mean flow of record, as measured at the Highway K-23 gauge near the proposed dam site, is 44 cubic feet per second (cfs) with historic monthly averages ranging from five cfs to 330 cfs. Heimann and Tortorelli (1988) reported an average annual discharge for the Cimarron River near Mocane, Oklahoma as 101 cfs, based on 24 years of record. They reported extensive diversions for irrigation above the station. These irrigation diversions are also common in Kansas.

The Cimarron River is the only free-flowing river in Kansas, over 125 miles in length, which does not have any major physical alterations. It is also the only such river in the entire southern Great Plains (Benke 1990). Additionally, the portion of the river to be impounded by the proposed Forgan Dam has been designated by the National Park Service as a "significant free-flowing stream", noted mainly for outstanding scenic, geologic, and historic features.

The proposed dam and reservoir would be located in a remote part of Meade County, Kansas, on the Cimarron River, and includes a small portion of Beaver County in Oklahoma (Figure 1). The dam and reservoir would directly affect about three landowners, all part of the expansive Adams (or X-I-T) Ranch. The management of this area has remained virtually unchanged for nearly 100 years. Cattle ranching and oil production are the primary land uses on this ranch. Limited crop production for winter cattle feeding also occurs. Public access has always been limited due to natural topographic features, lack of roads, and control by private landowners.

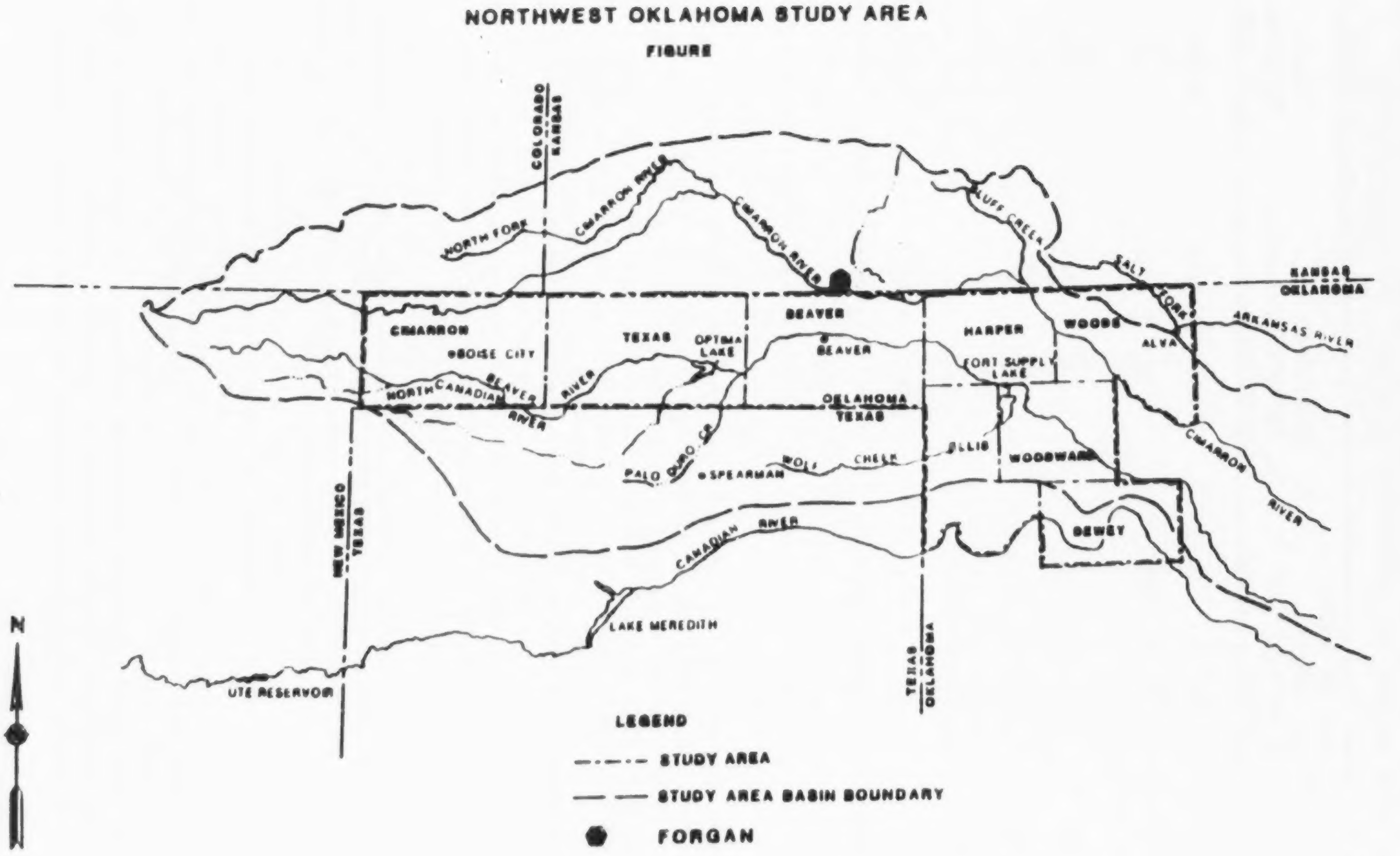
Description of the Project

The proposed Forgan Dam and Reservoir would be developed to provide municipal and industrial water supply for three counties in Oklahoma and the city of Liberal, Kansas. The Bureau is also evaluating flood control, recreation, fish and wildlife, and wetland enhancement as additional project purposes. Irrigation uses are not being considered for this proposed project.

The proposed Forgan Dam would be constructed 6.5 miles north of Forgan, Oklahoma. The dam site is located about one mile west of the Highway K-23 bridge over the Cimarron River. The reservoir created by Forgan Dam would extend up the valley for about seven miles and have a surface area of approximately 3,900 acres. At capacity, the reservoir would store about 35,000 acre-feet of water. The pipeline intake for water supply would begin near the dam site with approximately 572 miles of pipeline to be constructed. Anticipated releases to the pipeline and to the river are found in Table 1. These are projected flows once the reservoir is at conservation pool.

Aquatic and Terrestrial Resources without the Project

Major vegetative cover types within the Forgan Dam and Reservoir area include grassland (a mixture of sandsage and bluestem-grama prairies), cropland, riparian woodland, and wetlands. Riparian vegetation, unique subirrigated Grasslands compose the majority of wildlife habitats within the project area.



NORTHWEST OKLAHOMA STUDY AREA

FIGURE

COLORADO
KANSAS
NORTH FORK
CIMARRON RIVER
CIMARRON RIVER
BLUFF CREEK
SALT FORK
KANSAS
OKLAHOMA
ARKANSAS RIVER
CIMARRON
BOISE CITY
TEXAS
OPTIMA LAKE
BEAVER
BEAVER
HARPER
FORT SUPPLY LAKE
WOODS
ALVA
NORTH CANADIAN RIVER
BEAVER RIVER
OKLAHOMA
TEXAS
ELLIS
WOODWARD
CIMARRON RIVER
PALO DURO CR.
SPEARMAN
WOLF CREEK
NEW MEXICO
TEXAS
CANADIAN RIVER
DEWEY
LAKE MEREDITH
UTE RESERVOIR
TEXAS
OKLAHOMA
N
LEGEND
STUDY AREA
STUDY AREA BASIN BOUNDARY
FORGAN

Figure 1- Location of Northwest Oklahoma Water Supply study area and Forgan reservoir site.

Table 1. Anticipated releases proposed from Forgan Reservoir for northwest Oklahoma water supply and downstream releases.

Month	Northwest Oklahoma Water Supply Releases (acre-feet)	Downstream Releases (acre-feet)	Total Releases (acre-feet)
October	1,100	1,200	2 300
November	900	0	900
December	1,200	0	1,200
January	1,200	0	1,200
February	1,400	0	1,400
March	1,400	0	1,400
April	1,900	0	1,900
May	1,600	0	1,600
June	1,400	1,400	2,800
July	1,300	2,100	3,400
August	1,000	2,200	3,200
September	1,100	1,700	2,800
Total	15,500	8,600	24,100

meadows, springs, beaver ponds, sandbars, and grassland form a unique river bottom ecosystem found along the Cimarron River. Low water tables and upstream water diversions have caused this valuable ecosystem type to become extremely limited in southwestern Kansas. Table 2 summarizes cover type acreages for each project feature.

Good grazing management practices on this site allow wildlife habitat to range from fair to good. Dominant grassland plant species include sand, big, and little bluestems, sand lovegrass, blue and hairy grama, buffalograss, western wheatgrass, sandsage, and broom snakeweed. There is scattered yucca, prickly pear, and sand plum, with Russian olive in lower areas.

Cropland is the next most abundant habitat and occupies about seven percent of the total acquisition area. It primarily produces sorghum, alfalfa, and some wheat and is irrigated by center-pivots. This cropland provides cattle winter feed for the entire X-I-T ranching operation.

Riparian woodland consists of scattered willows and scattered mature cottonwood groves within the floodplain. Because of depleted streamflows, and reduction in widespread annual flooding, regeneration of cottonwoods has been suppressed. Subsequently, Russian olive has started rapidly invading.

A variety of wetland types occur on the project site within the Cimarron River floodplain. Some of these include unvegetated sandbars and shifting sand bottom within the river; subirrigated meadows with sedges, rushes, cordgrass,

Table 2. Cover types and acreages included within the Forgan Reservoir project site.

Cover Type	Conservation Pool (acres)	Flood Pool (acres)	Project Acquisition (acres)
Grassland	3,026 (77.6%)	4,862 (78.4%)	9,271 (86.7%)
Cropland	349 (9.0%)	662 (10.7%)	706 (6.6%)
Wetland			
emergent	337	410	433
scrub-shrub	33	65	
	370 (9.5%)	475 (7.7%)	498 (4.7%)
River			
unconsolidated bottom	116	146	170
unconsolidated shore	12	12	12
	128 (3.3%)	158 (2.6%)	182 (1.7%)
Riparian woodland	27 (0.7%)	43 (0.7%)	43 (0.4%)
Total area	3,900	6,200	10,700

saltgrass, foxtail barley, and spikerushes; a scrub-shrub community consisting of salt-cedar, willows, a mixed herbaceous layer; and other wetlands associated with fresh and saline springs, beaver ponds, and backwater areas.

The Cimarron River floodplain downstream of the Forgan Dam contains numerous wetland types (including riverine unconsolidated bottom, riverine unconsolidated shore, palustrine scrub/shrub, palustrine emergent, and palustrine forested). These provide habitat for a great diversity of resident and migratory species. This riparian zone and its functions and values were described by Stinnett and Smith (1987). In addition to providing wildlife habitat, the riparian zone provides floodwater retention, filtration of sediment, nutrient recycling, and groundwater recharge. Table 3 indicates the estimated amount of wetlands currently found within the 334 miles of the Cimarron River below the proposed dam site.

The distribution pipeline rights-of-way currently under consideration would occupy a total of 5,544 acres. Pasture/cropland is the most common habitat type within the pipeline route (5,374 acres). Upland forest makes up 108 acres of the right-of-way, and wetland types constitute 62 acres.

Table 3. Estimated acreage and related data for wetlands along the Cimarron River below Forgan Dam (Source: Stinnett and Smith 1987).

	River Section			
	Western	Central	Eastern	Total
Riparian Width (ft)[1]	2,768	2,071	787	--
Acres/River mile	355	251	95	--
Miles of River	108	95	131	334
Wetland Acres	38,340	23,845	12,445	74,630

[1] Stinnett and Smith (1987) defined riparian as forestland, shrubland, or emergent/open water wetland that had not been subjected to mechanical alteration and was adjacent to the stream channel and its sandbars. Riparian width was defined as a collective measurement of native wetland vegetation along each side of the riverine system.

Threatened and Endangered Species

Federally listed threatened and endangered species which could occur in the Forgan project area include the piping plover (*Charadrius melodus*), interior least tern (*Sterna antillarum*), bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), whooping crane (*Grus americana*), and black-footed ferret (*Mustela nigripes*). Each of these species is also listed as threatened or endangered by the States of Oklahoma and Kansas.

The piping plover is a seasonal migrant through this area and uses shallow wetlands and river sandbars for resting and feeding areas. It does not nest in Kansas, but occurs during the spring and fall when it and numerous other shorebird species pass through.

The interior least tern utilizes habitats very similar to those used by the piping plover and it occurs as a nesting species in this area. A colony is located on sandbars approximately one mile east of the Highway K-23 bridge, just downstream of the proposed dam site. Many colonies are found along the Cimarron River in Oklahoma.

The bald eagle winters along several rivers in Kansas and Oklahoma and has been observed in the project area. It prefers areas of open water, particularly where large trees provide perches from which it can fish or hunt. Fish and waterfowl comprise its primary winter diet, but small mammals and carrion are also eaten as available.

Peregrine falcons occur as seasonal migrants through Kansas and Oklahoma, occurring in areas where there are concentrations of waterfowl and small birds which compose their prey. Wetlands are a primary habitat type.

Whooping cranes migrate through Kansas and Oklahoma during April and May and again during October and November, using shallow wetlands, wet meadows, and river sandbars. They have been reported from Meade County, along with many sandhill cranes, and could likely occur along this stretch of the Cimarron River.

Black-footed ferrets are believed to occur almost exclusively in prairie dog colonies, feeding on prairie dogs and living in their burrows. Ferrets may occur in single prairie dog towns or in a complex of smaller towns. A complex consists of a cluster of individual dog towns within 4.5 miles of one another. If a town or a complex of 80 acres or more is to be impacted, a ferret survey should be conducted by certified personnel. While it is unknown whether black-footed ferrets still occur in the wild in Kansas of Oklahoma, some of the most promising potential sightings of this animal to be reported in recent years have come from southwest Kansas in the Cimarron River valley.

If plans for this project progress to the feasibility stage, the Bureau must prepare a Biological Assessment which addresses potential impacts to each of these listed species, and make a determination of whether there may be an effect on any of these species. If no effect is anticipated, there is no need for further endangered species coordination. However, if it is determined there may be an effect, formal consultation should be initiated pursuant to Section 7 of the Endangered Species Act.

In addition to the above listed species, the following category 1 and 2 candidate species may occur in the Forgan project area:

Species	Occurrence
Arkansas River shiner (Notropis girardi)	Cimarron River
Arkansas darter (Etheostoma cragini)	Springs and marshes along river
Texas horned lizard (Phrynosoma cornutum)	Sandy soil grasslands
Texas garter snake (Thamnophis sirtalis annectanus)	Various habitats
White-faced ibis (Plegadis chihi)	Wetlands, riverine
Ferruginous hawk (Buteo regalis)	Open areas, perch sites
Mountain plover (Charadrius montanus)	Grasslands, fields
Western snowy plover (C. alexandrinus nivosus)	Wetlands, riverine
Long-billed curlew (Numenius americanus)	Grasslands, wetlands
Migrant loggerhead shrike (Lanius ludovicianus migrans)	Grasslands, shrubby areas
Kansas bog lemming (Synaptomys cooperi paludis)	Wetlands
Swift fox (Vulpes velox)	Grasslands

Category 1 species are those for which sufficient information exists to support a listing decision. The Arkansas River shiner is the only category 1 species on this list. Category 2 species are those for which the Service is seeking additional information regarding their biological status. Candidate species have no legal protection under the Endangered Species Act unless and until they may become listed; however, the Service is concerned with their conservation due to their uncertain status. A consideration of the potential impacts from this project on these candidate species would be consistent with the spirit of Section 7 of the Endangered Species Act.

It is believed likely that [illegible] listing action for the Arkansas River shiner will be initiated sometime next [illegible]. While the listing process can take two years or more, the consensus is this fish warrants Endangered Species Act protection, and listing is expected to be accomplished. The Arkansas darter has also been recommended for listing, although this may not occur until a later time.

Both fish have been reported from the project area in the past. They are both listed by the State of Kansas as threatened or endangered and as "species of special concern" in Oklahoma. Kansas lists the following additional species as threatened or endangered and likely to occur in the project area: checkered garter snake, eastern hognose snake, eastern spotted skunk, flathead chub, Kansas glossy snake, New Mexico blind snake, snowy plover, Texas longnose snake, and each Federal listed species previously mentioned. The project sponsors and Bureau should consult with Kansas and Oklahoma to determine their responsibilities under State statutes regarding threatened and endangered species.

Aquatic Resources

Fishery habitats potentially affected by the proposed project include the Cimarron River, small intermittent streams, permanent springs, seeps, and beaver ponds. Within the project area the Cimarron River has a broad and uniformly sandy aggraded channel. Habitats for fishes consist mostly of long shallow "runs" over shifting sand, interrupted by relatively small, shallow pools and backwaters along banks and exposed sandbars.

Between the US-54 and K-23 bridge crossings flow increases greatly, apparently due to intervening exposures of water-bearing Ogallala sands along the floodplain (Geological Map of Kansas, State Geological Survey, Lawrence). Inspection of flow duration and discharge graphs for the gauging station located at the K-23 bridge indicates a rather flat nature of the discharge, seasonally as well as cumulatively, over the period of continuous record (1965 to present) (Cross et al. 1985). The low variability probably results from the groundwater discharge immediately upstream from the gauging station. The numerous springs, seeps, and subirrigated meadows within the project area also substantiate the theory that the Cimarron River within the project area is a gaining system.

Seventeen fish species have been recorded from the Cimarron River in Morton, Grant, Seward, Meade, and Clark Counties (Table 4). Two species were introduced (Red River shiner and mosquitofish), and the largemouth bass and channel catfish may no longer be indigenous to this area. Although the Cimarron River maintains only a minimal sport fishery, it's waters are of extreme importance to state and potential federally protected endemic fishes.

Pigg (1987 and 1988) described the fish species and the aquatic habitats of the Cimarron River in Oklahoma. At one site in Harper County he recorded 16 species, and at one site in Woods County he found 19 species. Cumulative fish community rating values (based on 16 parameters) for these two sites were poor. Sites further downstream had higher ratings, due mainly to the river being larger and there being more diverse fish habitat available. Two species in particular, Arkansas River shiner and Arkansas darter, were of concern in his studies due to an apparent decline in numbers and occurrence in the Cimarron. Change in flow regime, resulting from a dropping water table and drying up of springs, was cited as the probable cause of decline in numbers and distribution of these species.

Table 4. Fishes recorded in the Cimarron River in Kansas from 1962 to 1987 (Cross et al. 1985).

	Counties				
Fish Species	Clark	Meade	Morton	Grant	Seward
Arkansas River shiner	X				
Sand shiner	X				
Fathead minnow	X				
Plains killifish	X			X	
Red shiner	X	X	X	X	X
Flathead chub			X		
Black bullhead	X		X		
Green sunfish	X		X		
Plains minnow	X	X		X	X
Mosquitofish	X	X		X	X
River carpsucker	X				
Arkansas darter	X	X			X
Red River shiner	X	X			
Channel catfish	X				
Orange-spotted sunfish	X				
Largemouth bass	X				
Suckermouth minnow		X			

Meade and Clark counties are the only locations where the Arkansas River shiner is believed to persist in Kansas. It has been sampled fairly recently just downstream of the Forgan dam site. It may still also persist in the Cimarron River in Major and Payne Counties in Oklahoma. We assume this fish and the Arkansas darter naturally reproduce in the project area.

The Arkansas darter has been sampled on the Cimarron River within the project area in Kansas, as recently as 1987 (Boyd 1987). It has also been sampled in Harper County, Oklahoma (Pigg et al. 1985). Arkansas darters occur primarily on tributary streams near spring sources where the water temperatures remain generally below 80° F. during summer extremes. The species is almost always associated with broad-leaved aquatic vegetation (U.S. Fish & Wildlife Service 1989).

Terrestrial Resources

A terrestrial resource inventory was not conducted for the Forgan project as funds and time for such an investigation were not available for this feasibility study. Without benefit of a complete terrestrial resource inventory, especially considering the historically limited access the Adams Ranch has maintained, a full appreciation and understanding of important species and habitats within the project area cannot be realized. For the purposes of this report, we have attempted to identify the major terrestrial species we currently believe inhabit the area of direct project impact. Unfortunately, there is little quantitative information currently available on wildlife or their habitats in the project area.

The unique interface or edge effect created by the river and various vegetative cover types and their collective value to wildlife form an extremely important ecosystem. Riparian, wetland, and adjacent upland habitats of this kind combine to make one of the most productive wildlife areas in western Kansas, supporting greater numbers and diversity of wildlife than any other ecotype. Low human populations, scarce roads, and strictly restricted access has made the Cimarron River valley even more valuable to wildlife.

Some species using the grassland habitat in the project area include mule deer, coyote, swift fox, badger, bobcat, ground squirrels, black-tailed prairie dog, black-tailed jack rabbit, desert cottontail, prairie rattlesnake, Texas horned lizard, ornate box turtle, lesser prairie chicken, golden eagle, prairie falcon, burrowing owl, Cassin's sparrow, and horned lark. Lesser prairie chickens numbers are apparently higher in the vicinity of the reservoir site than elsewhere in the region.

Croplands are used by wildlife primarily in fall and winter. They provide a high energy food source for migratory waterfowl, sandhill cranes, wintering sparrows, meadowlarks, bobwhite quail, ring-necked pheasant, prairie chicken, and white-tailed and mule deer. The value of this habitat is somewhat limited because the cropfields are clustered in one area.

The riparian woodland habitat is very important to several species. Large flocks of Rio Grande wild turkeys roost in these trees. Many raptors use the trees for roosting and nesting including redtail and Swainson's hawks, American kestrel, great horned owl, Mississippi kite, and golden and bald eagles. There is unconfirmed golden and bald eagle nesting in the project area. Raccoons, porcupines, woodpeckers, mourning doves, northern and orchard orioles, and many other migratory birds also use the riparian woodland.

The wetlands in the Cimarron River floodplain provide the most diverse habitat in the study area. Because of the permanent water source, most wildlife species in the project area spend at least a portion of their time in these wetlands. Some species found here include least tern, spotted sandpiper, snowy plover, ring-necked pheasant, several waterfowl species, bobwhite quail, turkey, beaver, striped skunk, eastern cottontail, cliff swallow, eastern and western kingbirds, common yellowthroat, kingfisher, several other migratory birds, and amphibians and reptiles. Large numbers of sandhill cranes and geese use these areas during migration. Waterfowl production occurs on the wetlands in summer and thousands of mallards use the area during winter. Large beaver ponds, some over two acres, provide duck and geese brood habitat and habitat diversity. The subirrigated meadows provide high quality year-round forage for deer. A good white-tailed deer population exists in the river floodplain and mule deer periodically use this habitat.

Aquatic and Terrestrial Resources with the Project

Fish and wildlife resource impacts associated with the Forgan project may not be fully understood based on our current scientific knowledge of the project area. Major data gaps, with both aquatic and terrestrial resources, precluded an inclusive analysis at this time. In response to Bureau reporting timeframes, and in keeping with the request for a Report, an attempt was made to identify major impacts, additional data needs, and make appropriate recommendations based on current levels of planning information. Recommendations contained herein assume the Forgan project could be built, but not without further investigation of fish and wildlife resources and impact analyses. Based on these limitations, specific wildlife recommendations could be nullified and/or modified as a result of future improved knowledge of the project area of impact, or in response to biological opinions under Section 7 of the Endangered Species Act.

Aquatic Resources

Construction and operation of the Forgan project would result in aquatic habitat alterations on the Cimarron River both upstream and downstream of the dam. Forgan Dam would cause the inundation of approximately seven miles of river to form a broad, deep reservoir. An additional three miles would be included in the flood pool. This stretch of the Cimarron encompasses the majority of the permanent flow remaining in Kansas. The resultant physical changes from riverine to deepwater habitats would favor the proliferation of existing and introduced exotics over native river fishes. It would also directly impact aquatic habitats currently occupied by Arkansas darters and Arkansas River shiners.

Further, Forgan Dam would release flows downstream thus contributing more exotic fishes to existing populations downstream. Changes in volume of flow, timing of release, and temperature, all of which appear to be critical to spawning success for Arkansas River shiners, are also expected downstream of the dam. According to the Draft Reservoir Operation Study, no releases from the dam into the river would be made for seven months (Table 1). This lack of flow would alter the hydrology of the floodplain, and disrupt the fluvial processes associated with the river system. The reduced flows would severely impact available fish habitat, and could cause further decline in sensitive species.

The seriousness of these potential impacts, and what they ultimately mean to the future conservation and recovery of these candidate fishes, both in the reservoir site and downstream of the dam, is not fully understood at this time. Should ongoing listing efforts and scientific study indicate a means by which the project could be constructed, consistent with requirements of the Endangered Species Act, measures specific to conservation and recovery of endangered fishes would be recommended. Such measures might include creation or modification of habitat downstream of the dam, maximizing flow regimes favorable to life requisites of downstream rare and protected fishes, and funding of research to better evaluate impacts of water depletion, sedimentation, and water quality changes on the life histories of fishes.

Consistent with the assumption that the Forgan project could be built is the assumption that the reservoir would be managed to provide a sport fishery designed to accommodate projected fisherman use. Predicted use, based on a 3,900 acre surface area, is approximately ten trips per acre (Gabelhouse, personal communication). Net fishery benefits of about $900,000.00 annually with this management plan represents 100% enhancement since existing fishermen use is presently insignificant. The costs associated with establishment of a warm water fishery is approximately $165,000.00.

From a fishery management standpoint, better biologically workable scenarios for fisheries enhancement and species mixes would become apparent during future project planning. They could include stage area filling of the impoundment, habitat structure creation, potential establishment of a cool water fishery, and development of reservoir water level management plans.

Terrestrial Resources

A. Impact Analysis -

At the request of the Bureau, the HEP values developed and used in the Service's Report (1988) were used to evaluate potential terrestrial impacts associated with the development of Forgan Reservoir. Habitat values were previously determined by the Service's Tulsa Field Office using a subjective modified Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service 1988). Values could range from 0 to 10, with 10 being the highest. Values for the site included: grassland - 4.2, cropland - 5.3, wetland - 4.2, and riparian woodland - 5.7.

We believe these relative values are low for the specific area to be affected, although they may be representative of this region. From our site visit through portions of the project area, cattle grazing was well managed and grassland and wetland habitats were not heavily grazed. Information we received regarding the species using the site also indicate habitat values would probably be higher. A more objective and thorough evaluation of wildlife habitat at the project area would be accomplished using the Service's detailed HEP methodology.

B. Terrestrial Resource Losses -

We expect all species of terrestrial wildlife that inhabit the Forgan site would be sharply reduced, and some eliminated, due to inundation and significant increases in human disturbance. Adjacent habitats are at or near carrying capacity and would not immediately accommodate displaced animals.

We assumed all habitat types would be inundated and lost at conservation pool level. We assumed that with the project in place, all habitat types would be significantly altered between conservation and flood pool elevations with habitat values lowered by one-half. Vastly increased human use of project lands following reservoir construction would also decrease the use of these habitats by wildlife.

Table 5 shows resource losses totalling 21,807 habitat units (5,047 acres) would occur from conservation and flood pool inundation. As mentioned previously, these figures were obtained from a subjective evaluation. An objective multiagency evaluation must be done if project planning continues. Since information isn't yet available on borrow areas, spillway construction, roads, parking lots, and recreation developments to be included with the proposed project, we did not evaluate those impacts. However, these

Table 5. Terrestrial resource losses due to proposed Forgan Reservoir.

Cover type	Habitat Value	Dam and Conservation Pool		Between Conservation and Flood Pools		Total Losses	
		acreage	habitat units[1]	acreage[2]	habitat units	acreage	habitat units
Grassland	4.2	3,026	12,709	918	3,856	3,944	16,565
Cropland	5.3	349	1,850	156	827	5,051	2,677
Wetland (including riverine)	4.2	498	2,091	65	273	563	2,365
Riparian Woodland	5.7	27	154	8	86	35	200
Total		3,900	16,804	1,150	4,992	5,047	21,807

[1] Habitat units equal habitat value multiplied by acreage.

[2] Acreage affected divided by two to reflect decrease in habitat value by one-half due to periodic flooding.

additional habitat losses, mainly grassland habitats, must also be mitigated.

The combination of good quality sandsage prairie and the riparian corridor along the floodplain creates a unique habitat situation supporting a variety of migratory birds, both nesting and migrant visitors, all of which are protected by the Migratory Bird Treaty Act (16 U.S.C. 703-712). Four of the grassland species which may occur in this area are also candidates for Federal endangered species listing including the ferruginous hawk, mountain plover, long-billed curlew, and migrant loggerhead shrike. Two wetland candidates, the western snowy plover and white-faced ibis, also occur here in addition to many other species. The inundation of seven miles of Cimarron River and its associated floodplain and prairie, plus alterations to downstream flow releases, may be expected to have an adverse impact on many migratory birds.

In accordance with the Migratory Bird Treaty Act, all agencies and individuals are obligated to preserve and protect migratory bird species from unauthorized and unregulated taking activities. This Act prohibits, by any means or in any manner, the direct or indirect capture, possession, or destruction of any migratory bird, its nest, its eggs, or its young, or any parts thereof. Destruction or removal of active nests, or destruction of habitat required for nesting or travel movements of a protected bird species, may be considered a taking activity under this Act. Species protected under the Act include all birds except the house sparrow, rock dove, European starling, and native gallinaceous birds such as turkey and quail. A more detailed habitat analysis should help identify specific impacts which might result from this severe habitat fragmentation, with mitigation subsequently determined.

Downstream impacts from the construction and operation of Forgan Dam can be projected at this early stage of planning based on studies of other river systems in western Oklahoma. The river corridor would be narrowed due to absence of flood flows and vegetation encroachment. The extensive unvegetated sandbars would become vegetated, mostly by salt-cedar. Nutrient transport from upstream sources would be eliminated, and major changes in wetland types within the floodplain would occur. Elimination of scouring flood flows would encourage land use changes within the floodplain, thus causing an increase of pasture and cropland on what was once wetland. These anticipated impacts could occur for the entire length of the Cimarron River downstream of Forgan Dam. Wetland acreage changes along the Cimarron and downstream of Forgan Dam are shown in Table 6 by outyear and river section.

The expected vegetation changes within the riparian zone of the Cimarron would also cause alteration of the numbers and diversity of wildlife species using the area. Shrub and woodland species would increase, while species utilizing wetland types would be displaced. The projected wetland losses were based on data gathered by Stinnet and Smith (1987). This data showed an average annual wetland acreage loss along the Canadian River of one percent per year over 30 years. Additional wetland losses would be anticipated along the Cimarron due to land use changes (including conversion of existing wetland habitat to agricultural uses) expected after alteration of normal flooding regimes.

The water distribution pipeline routes would result in temporary loss or alteration of 62 acres of wetlands, 108 acres of upland forest, and 5,374

Table 6. Expected wetland acreage remaining by outyear and river section with construction and operation of proposed Forgan Reservoir.

	River Section			
Outyear	Western	Central	Eastern	Total
0	38,340	23,845	12,445	74,630
1	37,957	23,607	12,321	73,885
10	34,506	21,460	11,200	67,166
20	30,672	19,076	9,956	59,704
30	26,838	16,691	8,711	52,240
50	19,170	11,923	6,222	37,315

acres of pasture/cropland. After construction, the pipeline rights-of-way would be expected to gradually return to present condition.

Changes to least tern habitat would also be expected downstream of the dam. Decreased flows would decrease the quality and quantity of suitable tern breeding areas many miles downstream of the dam. This would occur as vegetative encroachment increased due to stabilized flows and decreased recurrence of scouring flows. Kansas Department of Wildlife and Parks has undertaken habitat enhancement measures to improve tern breeding success in Meade County. Future success of additional habitat improvement projects on the Cimarron River would likely be hampered by Forgan Dam operations. Furthermore, tern food supplies could be affected if minimum flow releases from Forgan Dam were insufficient to maintain a healthy downstream "minnow" fishery.

Mitigation

The Service's primary objective for this project is to maintain the ecological integrity of the Cimarron River valley through protection of valuable fish and wildlife habitats, enhancement of existing habitat values, and other sound wildlife management practices. Our policy guidance in accomplishing this objective is contained in the Service Mitigation Policy (Federal Register 46(15): 7644-7663). Refer to U.S. Fish and Wildlife Service (1988) for a more complete discussion of mitigation planning goals.

Mitigation for stream habitat losses due to the Forgan project was reported in U.S. Fish and Wildlife Service (1988). The report recommended a fenced-off riparian/wetland corridor, at least 150 feet wide, be established along 7.5 miles of river upstream and/or downstream of the dam. This corridor would improve the quality of the river and help mitigate stream loss. We agree the corridor concept should be incorporated, although it does not fully offset the loss of seven miles of the river. Effects of this reservoir on species such as the Arkansas River shiner may not realistically be mitigated because of severely reduced stream flows. Further mitigation should include additional and more natural flows than those proposed in Table 1.

Mitigation for Dam and Reservoir Impacts-

Mitigation requirements for terrestrial losses were determined for habitat types by dividing habitat unit losses by management potential, where management potential was the difference between present habitat unit value and maximum potential value (Table 7). We again emphasize habitat values used in calculations are probably low, indicating additional mitigation would likely be required following future studies. Because wetlands must be replaced "in-kind", and there is a "no-net-loss of wetlands" federal policy, mitigation of wetland losses must be accomplished by wetland creation or restoration of similar wetland types.

Habitat management of project lands between the take-line and conservation pool could mitigate grassland habitat losses. Grassland management would entail improved grazing management, fencing, planting grassland vegetation on cropland, and other habitat management practices. As mentioned previously, additional mitigation would be required for all additional losses due to roads, recreation development, etc. Scattered groups of tree plantings between conservation and flood pools could mitigate the eight acres of riparian woodland losses to occur there.

Table 7. Acres of terrestrial cover types required for mitigation of direct project impacts.

Cover type	Habitat[1] Units Lost	Management[2] Potential	Mitigation[3] Acres
Grassland	16,565	5.8	2,856
Wetland (including riverine	2,365	4.2	563[4]
Riparian woodland	200	4.3	36
Total	19,130		3,454

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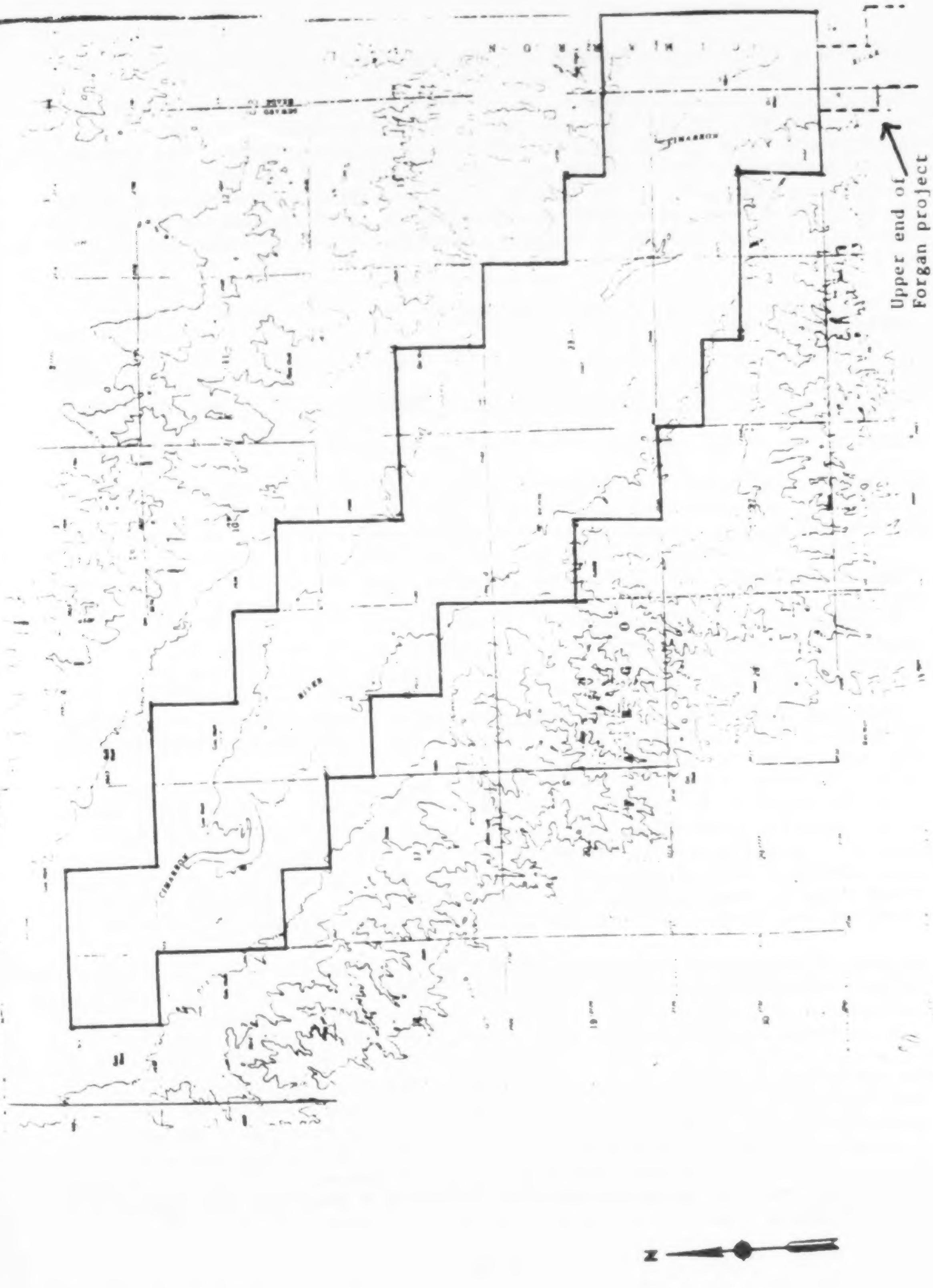
[1] Habitat units are preliminary and were determined using a subjective evaluation.

[2] Management potential is the difference between present habitat value and the maximum potential value of 10.0.

[3] Acres needed for mitigation = habitat units lost/management potential.

[4] Wetland losses must be mitigated by wetland creation or restoration.

For aquatic, riparian woodland, and wetland losses, we recommend acquiring additional land adjacent to and upstream of the project site for mitigation (Figure 2). This area is similar to that described for the Forgan site; however, detailed studies would identify existing habitat values, important fish and wildlife resources present, and more opportunities for protection and enhancement of the area. The Cimarron River is much narrower along this


CIMARRON
RIVER
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N

Upper end of Forgan project

Figure 2- Location of potential mitigation site.

stretch and is no longer permanent in the upper end of the site.

The mitigation site we tentatively identified to offset fish and wildlife resource losses contains approximately 5,050 acres (Table 8). The percentageof riparian woodlands is five times project site riparian woodlands. Wetland percentages are one and one-half times that of project site, and the candidate mitigation site has a much larger percentage of scrub-shrub wetland. The majority of the wetlands are in the lower half of the mitigation site. The river is wider here and the water table appears higher than the upper half.

Table 8. Cover types, acreages, and habitat values on proposed Forgan mitigation area.

Cover type	Acreage	Habitat Value[1]
Grassland	4,436 (87.8%)	4.2
Cropland	135 (2.7%)	5.3
Wetland (including riverine)	354 (7.0%)	4.2
Riparian woodland	95 (1.9%)	5.7
Total	5,050	

[1] A habitat assessment was not conducted at the mitigation site. Therefore, we used the same habitat values as those at the Forgan project site, although they may change following future studies.

We believe little can be done at existing woodlands to increase habitat values. Therefore, mitigation would take the form of woodland planting and development on the mitigation site. A total of 35 acres of trees would have to be replaced on mitigation site and project lands. Large trees (2 1/2 to 3" diameter) would be used to faster achieve the size of those lost.

Because of relatively flat slopes in the upper end of the reservoir, sand subsoil, windy conditions, and uncertain flexibility in water level management control, we assumed only those wetlands represented as river bottom and sand bars would be replaced in this upper end (about 145 acres).

As stated earlier, stream habitat losses could be partially mitigated by fencing a corridor along about 7.5 miles of the Cimarron River in the mitigation area. This could be in conjunction with fencing of wetland creation and riparian tree planting areas. Additional mitigation must include a more natural flow regime than proposed by the Bureau in Table 1. It must be made clear that replacing a river with a reservoir precludes mitigating all stream losses.

Wetland losses could be mitigated by creating wetlands within the floodplain. Because of the higher water table in the lower half of the mitigation area, wetland creation would be easier, less expensive, and more successful here. Excavating depressions down into the water table within the floodplain should help develop wetlands similar to those lost (Sousa 1987). These areas should be irregularly shaped and somewhat randomly placed. It would probably be necessary to excavate and stockpile the shallow soil layer, remove sand to desired depth, and replace top soil to get adequate wetland development. Aside from a nutrient source, this soil would also contain wetland plant seeds that could then vegetate the new wetland. This wetland creation outline is a simplification of detail needed to develop wetlands.

Following detailed studies on wetland development potential at the mitigation site, it may be determined wetland habitat losses cannot be fully mitigated there. Wetland mitigation could then take place elsewhere in the vicinity of the project. We suggest additional mitigation be accomplished by restoring some of the many drained playa lakes in the area. A buffer strip and long-term easement would be needed to ensure wildlife habitat values would remain.

The Bureau and Service's recently signed Memorandum of Understanding (MOU) concerns the protection, restoration, creation, and management of habitats for migratory birds and associated wetland species on Federal projects in response to goals set forth in the North American Waterfowl Management Plan. Opportunities exist to implement this MOU with the Forgan project including creating a very diverse wetland complex within the mitigation site. Included with, or adjacent to, this complex could be nesting habitat development for waterfowl and other wetland-dependent species. Small impoundments in the drier upper portion of the proposed mitigation site would further enhance the value of this tract. Additionally, food plots could be established for wildlife use. Bureau expertise and equipment could also be used to restore nearby drained playas.

The importance to wildlife of the Cimarron River floodplain cannot be overstated. The dramatic reductions in density and diversity of flora and fauna as one moves away from the valley on to the plateau further indicates its oasis-like value to wildlife. All life requisites for a number of species are accommodated in this relatively small area. The loss of the river and associated environments is irretrievable. Compensation based on habitat units may be achieved, but the physical loss of the riverine system is final.

We determined acquisition costs for the 5,050 acre mitigation tract at $2,525,000.00 based on the $500.00/acre figure used in our 1988 Report. In addition, five dwellings are located in the mitigation area and would have to be relocated. Wetland development costs were determined to be about $1,800.000.00, based on development of similar wetlands in North Dakota (Sousa 1987). Riparian tree replacement of 27 acres on the proposed mitigation area and eight acres on project lands would cost about $315,000.00. Fencing for grassland management, and protection of the stream corridor, wetlands, and tree plantings from grazing would cost about $350,000.00. Burning for grassland management would total about $8,000.00 annually. Annual operation, maintenance and replacement costs would total $3.50 per acre or $41,475.00 per year. Therefore, preliminary mitigation costs total $4,990,000.00, with annual costs about $50,000.00 per year.

Mitigation for Downstream Impacts-

The proposed Forgan Reservoir would result in alteration or loss of 37,315 acres of wetland habitat along the Cimarron River downstream of the dam over a 50 year period. The water supply distribution system would have a temporary and linear effect on 62 acres of wetland habitat. As mentioned earlier, our overall mitigation goal for wetland resources is no net loss of in-kind habitat value. Existing and projected land uses along the river, coupled with reduced flows, would preclude minimization of impacts, rectification of impacts, reduction or elimination of impacts over time by preservation and maintenance operations, or compensation for impacts by replacing or providing substitute resources or environments. The only reasonable mitigation for impacts of this magnitude is avoidance (and investigation of other alternatives to accomplish project goals). The Administration's policy of no-net-loss of wetlands can't be met under the current study since there are no suitable wetland areas available for consideration as potential mitigation sites.

Compensation for wetland losses from the water distribution system could be accomplished by Reclamation providing funding to the Oklahoma Department of Wildlife Conservation (ODWC). Increased management of existing wetland resources around Fort Supply Reservoir for the time required to return the disturbed areas to preconstruction conditions could provide compensation. For the purposes of this assessment, a period of five years was assumed to be adequate for the disturbed wetland areas to redevelop.

Construction and operation of Forgan Reservoir would also alter flows in the Cimarron River. Studies on Oklahoma streams (Orth and Maughan 1981) have shown minimum flows of 10 percent of the average annual flow during July through December and 30 percent during January through June are required to prevent degradation of stream fish habitat. Thus, a minimum continuous instream flow recommendation for the Cimarron below Forgan Dam would consist of 10.1 cfs during July through December and 30.3 cfs during January through June. They are preliminary estimates of minimum flow requirements for the Cimarron, and more detailed instream flow studies will be necessary if further planning is done on the project.

For early planning purposes, a land acquisition cost of $600.00 per acre for wetland habitat has been used by several agencies. Based on this figure, even if enough suitable wetland habitat was available, the 37,315 acres required for acre-for-acre replacement would cost $22,389,000.00, not considering initial development or annual operation and maintenance. Also, replacement of habitat value for these wetlands would likely require greater acreages than just acre-for-acre. Should further planning for this project occur, appropriate habitat-based studies (such as the Service's Habitat Evaluation Procedures) would be necessary to quantify the habitat value of the wetlands to be impacted. Based on an annual operation and maintenance cost of $35.00 per acre, the 62 acres of wetlands impacted by the water distribution system could be compensated by the Bureau contributing $2,170.00 annually to ODWC toward management at the Fort Supply Wildlife Management Area.

Recommendations

The following are minimum recommendations we request be considered if project planning continues on the proposed Forgan project:

1. Future studies should include detailed U.S. Fish and Wildlife Service Habitat Evaluation Procedures (HEP) and Instream Flow Incremental Methodology (IFIM) on project lands, the proposed mitigation area, and downstream impact areas.

2. A detailed breeding bird survey should be conducted to determine Migratory Bird Treaty Act implications, and impacts to Federal candidate species and other protected migratory birds.

3. Fall and winter bird surveys should also be conducted to determine more accurately the use of the project area by waterfowl, sandhill cranes, bald and golden eagles, and other migratory and protected birds.

4. There should be a survey for least tern nesting colonies on unsurveyed areas of the Cimarron River in Kansas and Oklahoma.

5. A detailed assessment of the Cimarron River fishery resource should be conducted in the pool area, upstream, and well downstream to determine aquatic impacts from both flooding and releases downstream.

6. There should be a characterization of vegetation and hydrology of wetlands in project area and proposed mitigation area to facilitate adequate mitigation.

7. There must be a Biological Assessment prepared (by the Bureau) outlining potential threatened and endangered species impacts.

8. A mitigation management plan should be developed in coordination with the Bureau of Reclamation, Fish and Wildlife Service, and Kansas Department of Wildlife and Parks.

9. There should be an evaluation of the potential for developing and maintaining a large prairie dog colony on the proposed mitigation area for potential use as a black-footed ferret reintroduction site.

Recommendations contained herein are offered in good faith and based on the best professional assessment of project impacts possible in view of existing Bureau of Reclamation reporting time frames and our current level of knowledge. Future changes in the project plan as a result of alternative formulation, design modifications, legal restraints, improved data bases, etc. may necessitate reassessment of impacts and new mitigation recommendations to fully satisfy Fish and Wildlife Coordination Act requirements.

Literature Cited

Benke, A.C. 1990. A perspective on America's vanishing streams. J. of N. Am. Benthol. Soc. 9(1):77-88.

Boyd, R.L. 1989. Habitat management and population ecology studies of the least tern in Kansas, 1989. Report to Kansas Game and Fish Comm., Pratt, KS.

Cross, F.B., R.E. Moss, and J.T. Collins. 1985. Assessment of dewatering impacts on stream fisheries in the Arkansas and Cimarron Rivers.

Gabelhouse, Dan. 1990. Kansas Department of Wildlife and Parks. Personal communication.

Heimann, D.C. and R.L. Tortorelli. 1988. Statistical summaries of streamflow records in Oklahoma and parts of Arkansas, Missouri, and Texas through 1984. U.S. Geol. Survey Water Resources Investigations Report 87-4205. 387 pp.

Hjelmfelt, A.T. and J.J. Cassidy. 1975. Hydrology for engineers and planners. Iowa State University Press, Ames, Iowa. 210 pp.

Orth, D.J. and O.E. Maughan. 1981. Evaluation of the "Montana method" for recommending instream flows in Oklahoma streams. Proc. Okla. Acad. Sci. 61:62-66.

Pigg, J., W. Harrison, and R. Gibbs. 1985. Records of the Arkansas darter, _Etheostoma cragini_ Gilbert, in Harper and Beaver Counties in Oklahoma. Proc. Okla. Acad. Sci. 65:61-63.

Pigg, J. 1987. Survey of fishes in the Oklahoma panhandle and Harper County, northwestern Oklahoma. Proc. Okla. Acad. Sci. 67:45-59.

________. 1988. Aquatic habitats and fish distribution in a large Oklahoma river, the Cimarron, from 1976 to 1986. Proc. Okla. Acad. Sci. 68:9-31.

Self, H. 1978. Environment and man in Kansas, a geographical analysis. The Regents Press of Kansas, Lawrence. 288 pp.

Sousa, P.J. 1987. Habitat management models for selected wildlife management practices in the northern Great Plains. U.S. Dept. Inter., Bur. Rec. REC-ERC-87-11.

Stinnett, D. and R. Smith. 1987. Riparian areas of western Oklahoma - a special study of their status, trends, and values. U.S. Fish and Wildl. Serv. and Oklahoma Dept. of Wildl. Conservation, Oklahoma City, Oklahoma 80 pp.

U.S. Bureau of Reclamation. 1989. Plan of study for completing the Northwest Oklahoma Water Supply Study. Denver, Colorado. Unpublished report.

U.S.D.A. - Soil Conservation Service. 1977. Soil survey of Meade County, Kansas. U.S. Dept. of Agriculture and Kansas Agricultural Exp. Sta. 53 pp. and maps.

U.S. Fish and Wildlife Service. 1988 - Planning Aid Report on modification of Ft. Supply Lake, and construction of Alva, Cold Springs, and Forgan Reservoirs. Unpublished report. 32 pp.

U.S. Fish and Wildlife Service. 1989. "Status report on Arkansas darter (Etheostoma cragini). Unpublished report.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Ecological Services
222 S. Houston, Suite A
Tulsa, Oklahoma 74127

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February 1, 1990

MEMORANDUM

To: Project Manager, Bureau of Reclamation, Oklahoma City, OK

From: Field Supervisor, Ecological Services, Tulsa, OK

Subject: Preliminary fish and wildlife mitigation information on Northwest Oklahoma Water Supply Study

Attached is the subject information in accordance with Information Milestone Number 1 of the recent Interagency Agreement on the Northwest Oklahoma Water Supply Study. Please note, as planning constraints: 1) the lack of adequate flow releases to maintain aquatic habitat, and 2) there are not suitable areas available in the vicinity of this project to provide the preliminary recommended compensation of 4,208 acres of wetland habitat. Therefore, under the Administration's "no net loss" policy regarding wetlands, this proposed alteration of Fort Supply Reservoir cannot be mitigated.

Information contained in this document will be expanded and updated in a planning aid report in July 1990.

Stephen

Attachments

cc (w/copy attachment):
Assistant Commissioner, Resource Management, Bureau of Reclamation, Denver, CO
Attn: D-5200
Director, Oklahoma Department of Wildlife Conservation, Oklahoma City, OK.
Attn: Environmental Section
Regional Director, Fish and Wildlife Service, Albuquerque, NM (FWE/HC)

KDF:dc

Preliminary Estimates of Mitigation Acreages and Costs
For Fort Supply Reservoir and Distribution System
For Northwest Oklahoma Water Supply Study

by

U.S. Fish and Wildlife Service
Tulsa Ecological Services
January 1990

INTRODUCTION

This U.S. Fish and Wildlife Service (Service) planning assistance document provides a portion of the preliminary information required by the Bureau of Reclamation (Reclamation) for developing water supply and distribution systems to meet future needs in northwest Oklahoma. This report identifies estimated habitat acreage losses and preliminary mitigation area (and cost) associated with the proposed modification of Fort Supply Reservoir and distribution pipelines. This planning assistance is submitted in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 601 et seq.), but is not intended to fulfill the reporting requirements of Section 2(b) of the Act.

METHODS

Habitat types and acreages were determined by delineating the existing Fort Supply Reservoir pool levels, proposed pool levels, and proposed pipelines on U.S. Geological Survey 7.5' topographic maps and the Service's National Wetlands Inventory maps. A digital planimeter was used to determine areas affected by the proposed rise in pool levels and the pipeline right-of-way.

DESCRIPTION OF THE PROJECT

Reclamation is considering the alteration of the existing Fort Supply Reservoir to provide for future water supply needs in northwest Oklahoma. Table 1 shows the existing and proposed conservation and flood pool elevations and acreages.

Table 1. Existing and proposed pool elevations and acreages for Fort Supply Reservoir, Northwest Oklahoma Water Supply Study.

	Existing		Proposed	
	Elev.	Acres	Elev.	Acres
Conservation Pool	2,004	1,820	2,015	~~2,554~~ (3350)
Flood Pool	2,028	5,690	2,033	~~6,504~~ (6600)

Approximately 329 miles of distribution pipeline right-of-way is also being considered by Reclamation to supply water from Fort Supply Reservoir to various communities and users in northwest Oklahoma.

FISH AND WILDLIFE RESOURCES

The Fort Supply project area includes the 5,418 acre Fort Supply Wildlife Management Area. This management area is administered by the Oklahoma Department of Wildlife Conservation (ODWC) under license from the U.S. Army Corps of Engineers, and provides habitat for a variety of species including quail, deer, turkey, rabbit, mourning dove, pheasant, waterfowl, and furbearers. The project area contains extensive wetland tracts around and upstream of the existing conservation pool. These wetlands include palustrine forest (cottonwood/willow mixture), scrub/shrub (mostly willow), and emergent (cattails, smartweed, sedges, and rushes). Cropland on project lands consists of share-cropped food plots maintained as part of an ongoing wildlife management program conducted by the ODWC. Crops grown include wheat, millet, and grain sorghum. The grassland /shrubland cover type consists of native grasses such as bluestems and gramas, various forbs, and shrubs such as sand sage and sand plum. Parkland includes the developed recreation and residential areas in the vicinity. Native and introduced grasses, cottonwood, and red cedar constitute the dominant vegetation in this cover type.

Wolf Creek is a perennial sand-bedded stream having its source in the Texas panhandle near Perryton. It flows eastward and then northeastward after entering Oklahoma to its confluence with the North Canadian (Beaver) River approximately 5.5 stream miles downstream of Fort Supply Reservoir. The total drainage area of Wolf Creek is approximately 1,739 square miles, with 1,498 square miles of the drainage area controlled by the reservoir. Prior to regulation by Fort Supply Reservoir in 1942 the average annual discharge in Wolf Creek was 104 c.f.s., and since regulation the average annual discharge has been 55 c.f.s.

MITIGATION

This section provides our initial estimates of wetland types and mitigation required with the rise in Fort Supply pool levels, based on existing information. Since these are preliminary estimates, they have limited value for project planning purposes. Use of the Service's Habitat Evaluation Procedures (HEP) and Instream Flow Incremental Methodology would be required at a later project phase to accurately quantify losses and mitigation needs.

The proposed conservation pool at elevation 2015 feet would eliminate a total of 1,683 acres of wetlands, including 1,085 acres of palustrine forested wetlands, 285 acres of palustrine scrub/shrub, and 313 acres of palustrine emergent wetlands. An additional 43 acres of wetlands would be affected by the pipeline routes (9 acres of palustrine forested wetland, 11 acres of palustrine scrub/shrub, 15 acres of palustrine emergent wetland, and 8 acres of riverine wetlands). Our overall mitigation goal for wetland resources is no net loss of in-kind habitat value. Although HEP studies have not been conducted on the area around Fort Supply Reservoir, a rough estimate of habitat quality was derived from other HEP studies in wetland habitats. These studies indicate that for every one acre of wetland habitat lost it would take 2.5 acres of wetland habitat to replace the habitat value of that one acre. Thus, for initial planning purposes estimates of mitigation acreage needed were determined by multiplying the area lost (acreage) by a conversion factor of 2.5. This conversion factor provides a simple method for determining preliminary estimates until a more comprehensive evaluation (Habitat Evaluation Procedures) can be conducted. Using the conversion factor, the amount of land needed to mitigate project related losses to wetlands would be: 1,683 acres x 2.5 = 4,208 acres.

The estimated cost per acre to purchase these lands would be $600, and initial development would cost $350 per acre. Therefore, total initial costs would be $3,996,800.

Acquisition of 4,208 acres x $600	= $2,524,000
Initial development of 4,208 acres x $350	= 1,472,800
TOTAL	$3,996,800
Annual maintenance cost at $10 per acre	$42,080

Also, approximately $9,000 would be required to reimburse the ODWC for federal aid money expended in development of the Fort Supply Wildlife Management Area. The proposed rise in pool levels would flood and/or disrupt a large portion of the existing Wildlife Management Area. Thus, a new license agreement with ODWC would be necessary, involving additional lands, fencing, roads, and initial development costs.

The impacts to wetlands due to pipeline construction would be relatively minor due to the linear and temporary nature of habitat disturbance. Mitigation of pipeline impacts could best be achieved through increased fish and wildlife habitat management around Fort Supply, rather than further acquisition. Estimated mitigation costs for pipeline impacts will be furnished in our final planning aid report in July 1990.

Parkland, grassland/shrubland, and cropland acreages (both existing and change expected with the project) have not been computed yet, but these types could be mitigated out-of-kind based on habitat value.

The proposal to raise Fort Supply Reservoir would also alter stream outflow into Wolf Creek. U.S. Geological Survey data indicate that the average annual flow in Wolf Creek approximately 1.5 miles downstream of Fort Supply Reservoir has been 55 c.f.s. since regulation. Reclamation data indicate that if the rise in pool levels occurred, the outflow from the dam would be zero for approximately 66 percent of each month.

Studies on Oklahoma streams have shown that minimum flows of 10 percent of the average annual flow during July through December and 30 percent during January through June are required to prevent degradation of stream habitat. Thus, a minimum continuous instream flow recommendation for Wolf Creek would consist of

5.5 c.f.s. during July through December and 16.5 c.f.s. during January through June, in order to minimize impacts expected with raising Fort Supply pool levels for water supply purposes. These are preliminary estimates of minimum flow releases and will likely change when additional data has been provided and appropriate instream flow studies completed. However, at this stage of planning, it appears that maintenance of downstream flows should be considered a major planning constraint.

Additional wetland habitat downstream of the project would be adversely impacted with implementation of the proposed project, and would require additional mitigation. Information concerning amount of habitat involved and mitigation required will be presented in a future planning aid report.

It is apparent even at this early stage of planning that insufficient acreage of wetland habitat is available in the project area to compensate for losses expected due to the proposed rise in pool levels. We recommend that Reclamation either drop this project from any further consideration or consider alternatives that would result in reduced impacts to wetland habitat types.

ATTACHMENT F
LETTERS OF COMMENT ON THE DRAFT REPORT

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
POST OFFICE BOX 61
TULSA, OKLAHOMA 74121-0061

REPLY TO
ATTENTION OF

[illegible]
FEB 06 [illegible]

4232

January 29, 1991

Planning Division
Basin Planning Branch

Mr. Gerald Wright
Bureau of Reclamation
420 West Main, Suite 630
Oklahoma City, OK 73102

Dear Mr. Wright:

We have completed our review of your Northwest Oklahoma Water Supply Study sub-feasibility report. Our comments and suggestions are enclosed.

We appreciate the opportunity to review your study dealing with the water supply needs of the northwest Oklahoma area. I hope these comments are useful.

Sincerely,

G. David Steele

G. David Steele, P.E.
Chief, Planning Division

Enclosure

REVIEW COMMENTS
NORTHWEST OKLAHOMA WATER SUPPLY STUDY

a. Operations and Recreational Related Facilities:

1. The project manager's quarters would be isolated if the proposed emergency spillway were ever utilized during top of flood surcharge pool conditions.

2. Comments pertaining to Table C-1, Fort Supply Estimate Cost for Relocations/Replacement of Recreation Related Facilities, follow:

a) Replace 4 single lane boat ramps with 2 double lane boat ramps. The unit price should be $18,000 each for a total cost of $36,000.

b) Replace Picnic Sites. The unit price should be $3,000 per site for a total cost of $125,000.

c) Replace Campsites. The unit price should be $3,000 per site for a total cost of $483,000.

d) Replace 3 Miles of Gravel Roads. The unit price should be $130,000 per mile for a total cost of $390,000.

e) Relocate Existing Double Restrooms (Waterborne). The total cost should be $130,000.

f) Relocate Existing Single Toilets. The unit price should be $1,000 each for a total cost of $10,000.

b. Geotechnical Aspects:

1. A roller compacted concrete emergency spillway over the existing embankment is not considered safe. The roller compacted concrete is not thick enough, could develop cracks and could wash off the downstream face if the flood pool (8 feet above the spillway crest) ever passes through the spillway. Failure of the spillway would probably result in failure of the earthfill section.

2. Reservoir Inflow: The study assumes inflows will not decrease, however, the historic annual inflow bar graph indicates that the computed annual inflow rate of 39,600 acre-feet was equaled or exceeded only 6 times in the past 27 years. Inflow rates have decreased at Optima and Forgan, and historical data suggests that inflow rates will decrease at Fort Supply. In this light, the 39,600 acre-feet inflow used in the report seems high. Provide information to describe the study inflow method and assumptions used in the computation. Historic records of inflow to Fort Supply Lake are available from the Hydrology Section, Tulsa District.

3. Study managers should consider the quantity of seepage presently going through the embankment foundation. This quantity will increase if the storage pool is increased. No documentation was given that evaporation and seepage losses have been considered in computing the available water quantity.

4. Forgan Site: The statements "Numerous subsidence features occurred in the dam/reservoir area," (page 61), and "It is probable that disturbed rocks, fissures, solution cavities, and/or caverns occur in the upper bedrock at the damsite," (page 62), indicate the proposed embankment location may not be acceptable. Discussion of the foundation treatment should substantiate the conclusion that the reservoir will hold water.

5. Outlet Works Profile: The following revisions are offered. Construct an intake tower at the upstream toe. Delete the gate chamber at the embankment centerline. This will eliminate a pressurized conduit. Do not expose the chimney drain at the embankment surface, provide at least 5 feet of cover. Delete the seep rings. Show suitable soil on D/S slope. Delete roller compacted concrete in the spillway (See Comment 1). Construct the spillway in a rock abutment. For cost analysis, use 1V on 3.5H embankment slopes.

c. Hydrology Comments: The estimated yield for Optima Lake, near the proposed Forgan Reservoir, in design documents was 10 MGD. During and after construction of the Optima project, the number of wells immediately above the dam have multiplied to such an extent that the river is a losing stream for virtually all of its length. These developments in the drainage area have contributed to an effective yield of zero for the Optima project.

d. Water Supply Projections. Over the past several years, the Oklahoma Water Resources Board (OWRB) has requested, through the Planning Assistance to States program, that the Corps of Engineers develop a state-wide computerized municipal and industrial (M&I) water supply needs system. Three of eight OWRB planning regions have been completed to date using the IWR MAIN computer model program. It is possible that this program could be used to validate Bureau of Reclamation projections. In addition, water conservation should be addressed for both M&I and agriculture. With modification of agricultural demands, through water conservation, there may not be a need for additional surface sources within the region for M&I water. The Great Plains Ogallala Aquifer Study, referenced in the bibliography, could be tied directly to this Northwest Water Supply Study in the Problems and Needs section in order to strengthen the demonstrated need for the proposed projects.

best copy available

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United States Department of the Interior
FISH AND WILDLIFE SERVICE
Ecological Services
222 S. Houston, Suite A
Tulsa, Oklahoma 74127

TAKE PRIDE IN AMERICA

DEC 28 1990

December 26, 1990

MEMORANDUM

TO: Project Manager, Bureau of Reclamation, Oklahoma City, OK

FROM: Field Supervisor, Fish and Wildlife Service, Ecological Services, Tulsa, OK

SUBJECT: Draft Special Report on Northwest Oklahoma Water Supply Study

We have reviewed the subject Draft Special Report, and note that both our planning assistance report on the Fort Supply option and the Manhattan, Kansas, Ecological Service office's planning aid report on the Forgan Reservoir option are included. We would like to submit the following specific comments on the Draft Special Report:

P. 83 - Apparently part of a sentence was left out after line 3.

P. 84 - The size and importance of the Oklahoma Department of Wildlife Conservation's management area at Fort Supply should be described.

P. 86 - Table 19 would be less confusing if the wetland types and acreages provided in our Feb. 1, 1990, planning assistance report were used in the table.

Our comments have been coordinated with the Manhattan Field Office to avoid repetition. We would like to emphasize that the issues of instream flows and wetland impacts downstream of the proposed Forgan Reservoir will require extensive analysis and detailed mitigation plans should further planning on the Northwest Oklahoma Water Supply Study be initiated. Please insure that the opportunity to comment on this Draft Special Report is provided to the Oklahoma Department of Wildlife Conservation.

Kenneth D. Frazier

cc:
Director, Oklahoma Department of Wildlife Conservation, Oklahoma City, OK
  Attn: Environmental Section
Regional Director, Fish and Wildlife Service, Albuquerque, NM (FWE/EC)
State Supervisor, Ecological Services, Manhattan, KS

KDF:dc

United States Department of the Interior
FISH AND WILDLIFE SERVICE
KANSAS STATE OFFICE
315 HOUSTON, SUITE E
MANHATTAN, KANSAS 66502
913-539-3474

DEC 23 1990

PRJ 3 NW

920
421

December 21, 1990

MEMORANDUM

TO: Project Manager, Bureau of Reclamation,
Oklahoma City, Oklahoma

FROM: Kansas State Supervisor, Fish and Wildlife Service, William H. Hill
Manhattan, Kansas

SUBJECT: Draft Special Report for Northwest Oklahoma Water Supply Study

This responds to your memorandum we received December 7, 1990, requesting our review and comments on the Draft Special Report for Northwest Oklahoma Water Supply Study. Our comments generally only address the Forgan Dam and Reservoir portion of your report. We provide the following comments for your consideration.

General comments- We are concerned that your report appears to downplay the potential environmental consequences of constructing and operating the proposed Forgan dam and reservoir. (1) Your report stated that we provided, in our 1990 Planning Aid Report (Report), a worst case analysis for mitigation and also stated that mitigation would probably be less than the total we determined; however, in our Report we stated that future detailed studies could, in fact, indicate increased mitigation requirements above those found in our Report are warranted. (2) Your report infers (pages 85 and 90) that the thousands of acres of grassland habitat to be lost from the proposed project do not need to be mitigated. However, we requested mitigation for this habitat because it is important to the area's biodiversity, it provides habitat for many migratory birds (which are protected by the Migratory Bird Treaty Act), and provides habitat for several State listed threatened and endangered species and candidate species for Federal listing. (3) Your report states that development of the dam and reservoir are not expected to impact any Federal or State listed threatened or endangered species; however, our Report clearly indicated the proposed project is expected to decrease the quality and quantity of some of these species' habitats.

We believe it is in your best interest, along with the best interest of the project area's aquatic and terrestrial resources, for potential environmental impacts to be addressed seriously now rather than after several more years of project planning. Aside from potentially saving the government a significant amount of money, it would illustrate the Bureau's commitment to the environment.

Specific comments-

- page 47, after first full sentence add- Another major drawback is that there would be significant impacts to fish and wildlife and important habitats at the reservoir site and hundreds of miles downstream.

- page 67, second paragraph, third sentence- delete this sentence. Service does not intend to try and develop a plan using downstream releases of only 7,100 acre-feet per year.

- page 81, fourth paragraph, delete everything after the first sentence and add- Within the proposed conservation pool, good grazing management practices allow wildlife habitat to range from fair to good quality. Dominant grassland plant species include bluestems, sand lovegrass, blue and hairy grama, buffalograss, western wheatgrass, sandsage, and broom snakeweed. Riparian areas of moderate habitat quality are also grazed. They are dominated by cottonwood, willow, and Russian olive. Upland woodlands (shelterbelts) also provide moderate habitat quality. Fair to good quality wildlife habitat is provided by about 370 acres of diverse wetlands which occur within the conservation pool.

- page 82, first full paragraph. Delete this paragraph because it is inaccurate. If wildlife species need to be included in your report refer to our Report for a more accurate list.

- page 83, Threatened and Endangered Species section - Only two Federal and one State listed threatened or endangered species discussed. The remaining four Federal and 15 State listed species we included in our Report should also be at least listed.

- page 83, third paragraph, change the first sentence to - In addition to the federally listed endangered species discussed above, three state listed fish species occur within the Forgan study area including Arkansas darter, Arkansas River shiner, and flathead chub.

- page 83, third paragraph, at the end of the second sentence add- and is a candidate for Federal listing.

- page 83, after third paragraph add- The Arkansas River shiner has also been found in the project area. This rare species is a candidate species for Federal listing. While the listing process may take two years or more, the consensus is this fish warrants Endangered Species Act protection, and listing is expected to be accomplished. The flathead chub has also been found in the Cimarron River mainstem and may be found in the project area.

- page 90, first complete paragraph- Grassland habitat needs to be included as one of the habitats whose losses need to be mitigated. This native sandsage grassland is an important component of the area's wildlife habitat and helps maintain the biodiversity of the region. It also helps form the unique river bottom ecosystem found along the Cimarron River. Furthermore, the grasslands affected by the project are important to many migratory birds, including four species which are candidates for Federal listing as threatened or endangered. Our Report lists your responsibilities under the Migratory Bird Treaty Act and Endangered Species Act.

- page 102, second paragraph- the additional threatened and endangered species listed in our Report need to be included.

- page 102, second paragraph, delete the fifth sentence which is incorrect. Add- Development of the dam and reservoir are expected to impact some of these species. If more detailed studies are undertaken a biological assessment would be included for threatened and endangered species.

We appreciate the opportunity to provide comments on your draft Special Study. If you have any questions or need further information contact me or Don Haley, of my staff, at (913) 539-3474.

cc: FWS, Tulsa, OK
KDWP, Pratt, KS
(Environmental Services Section)

KANSAS
WILDLIFE & PARKS

OPERATIONS OFFICE
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Pratt, Kansas 67124
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DEPARTMENT OF WILDLIFE & PARKS
MIKE HAYDEN, Governor
ROBERT L. MEINEN, Secretary
W. ALAN WENTZ, Assistant Secretary

C-TPO-USBR
JAN 07 1991

RESP 10

422

January 4, 1991

Donald Moomaw, Project Manager
Bureau of Reclamation
420 W. Main, Suite 630
Oklahoma City, OK 73102

Ref:D1.0300
Forgan

Dear Mr. Moomaw:

On December 28, 1990, we received a copy of the Bureau's Draft Special Report, Northwest Oklahoma Water Supply Study through the Kansas Field Office of the U.S. Fish and Wildlife Service. We are very disappointed that our office was not provided the courtesy of having direct contact from the Bureau with a request for comments on the report. The impacts of the proposed Forgan Reservoir, which is a part of the study, will largely accrue to Kansas wildlife resources for which this agency is responsible. As further drafts and documents are prepared and circulated, please be sure copies are provided to this office, ATTN: Environmental Services Section.

Regarding the draft document in question, although we have not been requested to do so, it has been reviewed and pertinent comments regarding its content are provided below. In general, we are disappointed in the somewhat cavalier presentation of significant adverse impacts to Kansas' wildlife resources that would result from the proposed Forgan Reservoir. We strongly recommend a more balanced presentation with those of other resources discussed.

Comments

Page 3: No General Map included (frontispiece) in the document we have. Please provide us with a copy.

Pg. 81, Para 4: The second sentence stating that grasslands at the Forgan site tend to be overgrazed and provide "poor-to-fair quality wildlife habitat" does not agree with the U.S. Fish and Wildlife Service's comments in their Planning Aid Letter dated September, 1990 (Attachment E). On page 4 of the PAL, the Service states "Good grazing management practices on this site allow wildlife habitat to range from fair to good."

The third sentence listing dominant grassland species also does not agree with the Service's PAL page 4. The colloquial term "tumbleweed" can refer to several different plant species and is inappropriate in professionally prepared document.

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Pg. 82, Para 1: This paragraph listing wildlife species occurring at the Forgan site does not accurately reflect the information provided on page 10 of the Service's PAL.

Ppg. 81-82, Terrestrial and Wetland Resources: This entire section's write-up appears to be a determined effort to denigrate the terrestrial wildlife values of the proposed project site as documented in the U.S. Fish and Wildlife Service's Planning Aid Letter. Since most of the proposed reservoir's terrestrial impacts would occur in Kansas, information documented by the Service's Kansas field office staff is the most accurate available at this stage of planning and should be included as provided.

Pg. 82, Aquatic Resources: Again, downplaying of existing resources as documented in the Service's PAL is evident. The proposed reservoir will be largely destroying Kansas's aquatic resources. The Service PAL documents 17 fish species occurring in the Cimarron in Kansas. Since the 16 species reported by the Oklahoma Department of Health are not shown, we have no way of knowing if there might actually be more than 17 species occurring. What fishery resource data is available from the Oklahoma Department of Wildlife Conservation? The appropriate wildlife agencies would be a more logical source for such resource information.

Pg. 83, Threatened or Endangered Species: There obviously has been an omission of narrative in this section. Again, the discussion presented in the Services PAL (pg 6-8) should be accurately reflected here.

An aspect of protection of threatened or endangered species not discussed pertains to current State of Kansas regulations protecting critical habitats for listed threatened and endangered species. The entire Kansas reach of the Cimarron River to be destroyed by Forgan Reservoir is designated critical habitat for the endangered Arkansas River Shiner (*Notropis girardi*) and Least Tern (*Sterna antillarum*), and threatened Arkansas Darter (*Etheostoma cragini*) and Snowy Plover (*Charadrius alexandrinus*). Under current regulations, before the project can be constructed, project sponsors must obtain a permit from this agency. Before such permit could be issued, we would have to be satisfied with mitigation measures to be incorporated in the project. The mitigation suggestions included in this report will not offset the probable impacts to listed threatened and endangered species.

The last sentence on page 102 is totally false in this regard. Forgan Reservoir will permanently destroy by inundation all critical habitat for the listed stream fishes below the reservoir flood pool elevation as well as downstream reaches of the river by dewatering, particularly during spawning periods. There are not mitigation measures currently proposed that would offset these losses of critical habitats.

In conclusion, we are totally opposed to public distribution of this document as written, nor should the document be used in any way as a representation of biological conditions as they currently exist at the site. We strongly encourage rewrite of those portions of the report commented upon above and similarly commented on by the Kansas Field Office of the U.S. Fish & Wildlife Service.

Sincerely,

Robert D. Wood

Robert D. Wood, Wildlife Ecologist
Environmental Services Section

bk

xc: Bur. Rec., Reg. Director, Billings
KDWP, Reg. 3. F&W Supv.
USFWS, KS Field Office

ROBERT S. KERR, JR.
Chairman
BILL SECREST
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Secretary
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ERVIN MITCHELL
DICK SEYBOLT

OKLAHOMA WATER RESOURCES BOARD
1957

P.O. BOX 53585 1000 N.E. 10TH STREET
OKLAHOMA CITY, OKLAHOMA (405) 271-2555
73152

JAMES R. BARNETT
Executive Director
MICHAEL R. MELTON
Assistant Director

FAX (405) 271-2740

DEC 28 1990

PRJ3
NW
421

December 27, 1990

Mr. Gerald L. Wright, Project Manager
Oklahoma-Texas Projects Office
Bureau of Reclamation
410 West Main, Suite 630
Oklahoma City, Oklahoma 73102

Dear Mr. Wright:

RE: Northwest Oklahoma Water Supply Study

Thank you for the opportunity to review the above referenced draft study.

I believe that it is obvious that the estimated $5.09 and $11.11 cost per thousand gallons at the Fort Supply Unit and Forgan Unit, respectively, would be economically prohibitive to the rural water suppliers in the study area.

However, we are convinced that the uncertainty surrounding the future dependability of groundwater as a future water supply source justifies continued investigation of developing surface water as an alternative and/or supplemental source.

Therefore, I would be interested in pursuing further discussions on the project costs and possible funding mechanisms.

I would also appreciate additional information on any alternatives that were studied to enhance flows or storage opportunities at Optima. The report referenced the Cold Springs Diversion to Optima, but the information provided was very cursory. An elaboration of the Bureau's findings would be appreciated.

If you have any questions concerning the above comments, please contact Ms. Terri Sparks or me at (405) 231-2500.

Sincerely,

James R. Barnett
Executive Director

TS/sb

LARRY M. BOSTIC
Executive Director

BEAVER
CIMARRON
DEWEY
ELLIS

O.E.D.A.

OKLAHOMA ECONOMIC DEVELOPMENT ASSOCIATION

Box 668
BEAVER, OKLAHOMA 73932
Phone 625-4531

HARPER
TEXAS
WOODS
WOODWARD

O-TPO-USBR
MAR 8 1991

March 6, 1991

W. Brooks Gallman
Area Planning Officer
U. S. Department of the Interior
420 W. Main Street, Suite 630
Oklahoma City, OK 73102

Dear Mr. Gallman:

During the February Board Meeting of the Executive Committee of the Oklahoma Economic Development Association, a review was conducted of the Northwest Oklahoma Water Supply Study. While finding the study to be a well written comprehensive study, the major concern of the Board was the cost of the projects, covered by the study. The Forgan Reservoir Site and the Fort Supply Reservoir Site both seem to be viable solutions if there could be some type of supplemental funds to defray the high costs per thousand gallons. The only other major concern dealt with the environmental impact.

It was suggested that certain areas deemed most in need of a good water supply be further studied as well as the feasability of regional wells that could serve several communities.

We appreciate the work done in Northwest Oklahoma by the Bureau of Reclamation and look forward to continuing our relationship. If you have any questions or suggestions, please contact me at your earliest convenience.

Sincerely,

Mike Bostic

Mike Bostic
OEDA Executive Director

MB/lm

XIT HEREFORDS

RAYMOND E. ADAMS JR
RAYMOND E. ADAMS III

THE ADAMS RANCH
MAPLE HILL, KANSAS
THE X I T RANCH
PLAINS, KANSAS

THE ADAMS CATTLE CO.
MAPLE HILL, KANSAS 66507

O-TPO-USBR
DEC 28 1990

990

421

December 26, 1990

Mr. Gerald L. Wright
Project Manager
Northwest Oklahoma Water Supply Study
Bureau of Reclamation
420 W. Main, Suite 630
Oklahoma City, Oklahoma 73102

Dear Mr. Wright:

Reference your Letter to me requesting comments on your Northwest Oklahoma Supply Study Draft Special Report.

I will concern myself mainly with the Forgan Damsite in these remarks as my Mother, Jessie S. Adams, and I are the principal landowners involved in this project. The land in this project has been owned and operated by my family for approximately 100 years. I have been an owner and operator of this land for the past 30 years. I am opposed to the Forgan Dam for numerous reasons. I will list a few of them, not in detail.

1. The project is impractical.
2. The flood plain would create a massive blow hole of sand.
3. I question your study figures, stream flow, length of river, etc. reference made to Optima Project.
4. Ruination of habitat for wildlife and endangered species.
5. Loss to ranch operations, of running water, irrigated land and subirrigated grazing, etc.
6. Water loss to landowners below damsite.
7. Poor water quality.
8. Dam will not hold water.

I feel that this is another example of a land grab by the Federal Government for which there is no justification. Be assured that we will oppose this project to the end.

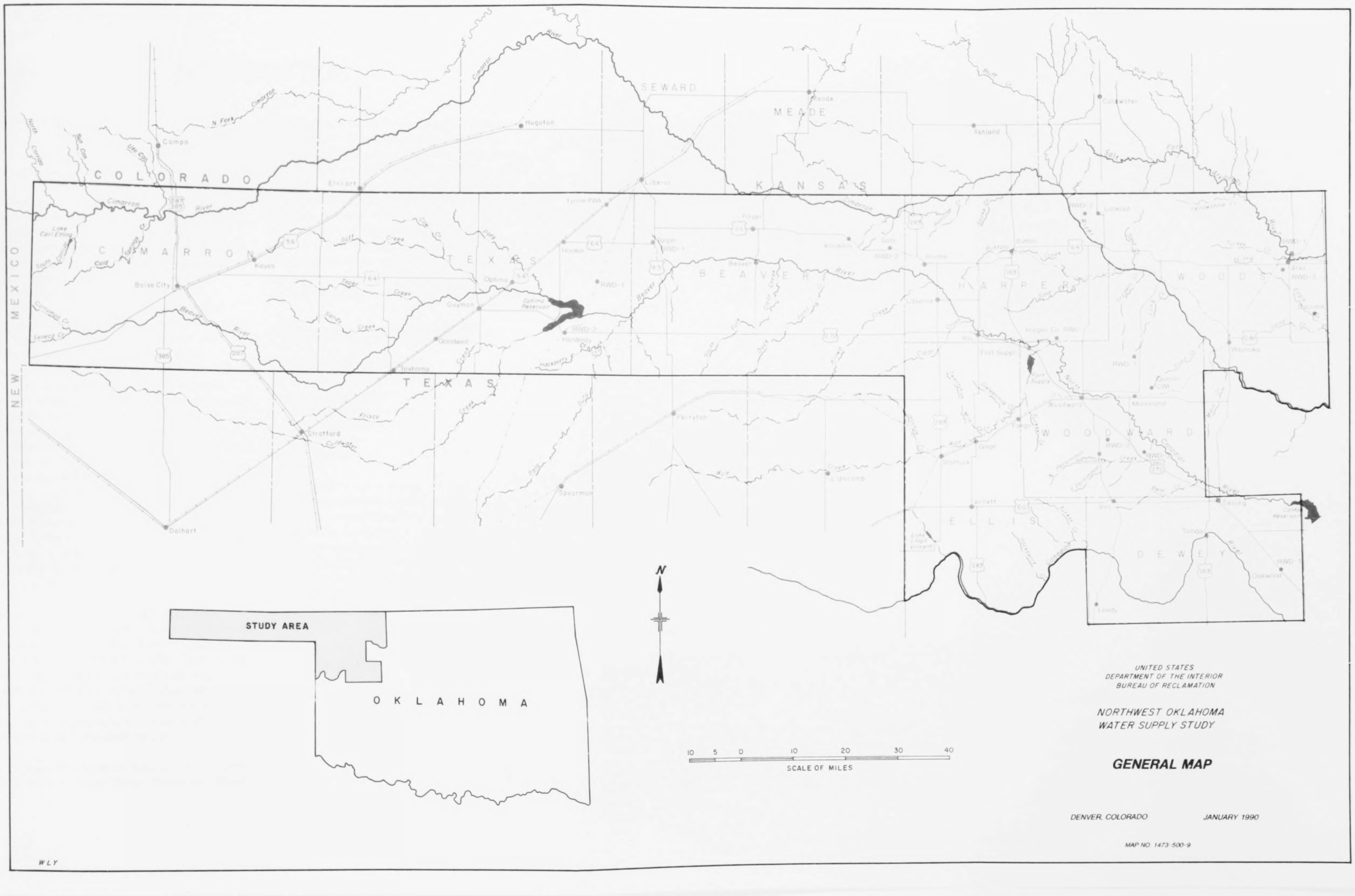
We do appreciate your keeping us informed on this matter and would look forward to discussing it with you at some future date.

Yours truly,

Raymond E. Adams, Jr.

Jessie S. Adams

REA:hl


COLORADO
KANSAS
NEW MEXICO
TEXAS
SEWARD
MEADE
CIMARRON
TEXAS
BEAVER
HARPER
WOODS
WOODWARD
ELLIS
DEWEY
Hugoton
Campo
Elkhart
Liberal
Meade
Ashland
Boise City
Keyes
Guymon
Goodwell
Texhoma
Optima
Hooker
Hardesty
Beaver
Stratford
Perryton
Spearman
Dalhart
Lipscomb
Fort Supply
Woodward
Gage
Shattuck
Arnett
Leedy
Cimarron River
Beaver River
STUDY AREA
OKLAHOMA
N
10 5 0 10 20 30 40
SCALE OF MILES
WLY

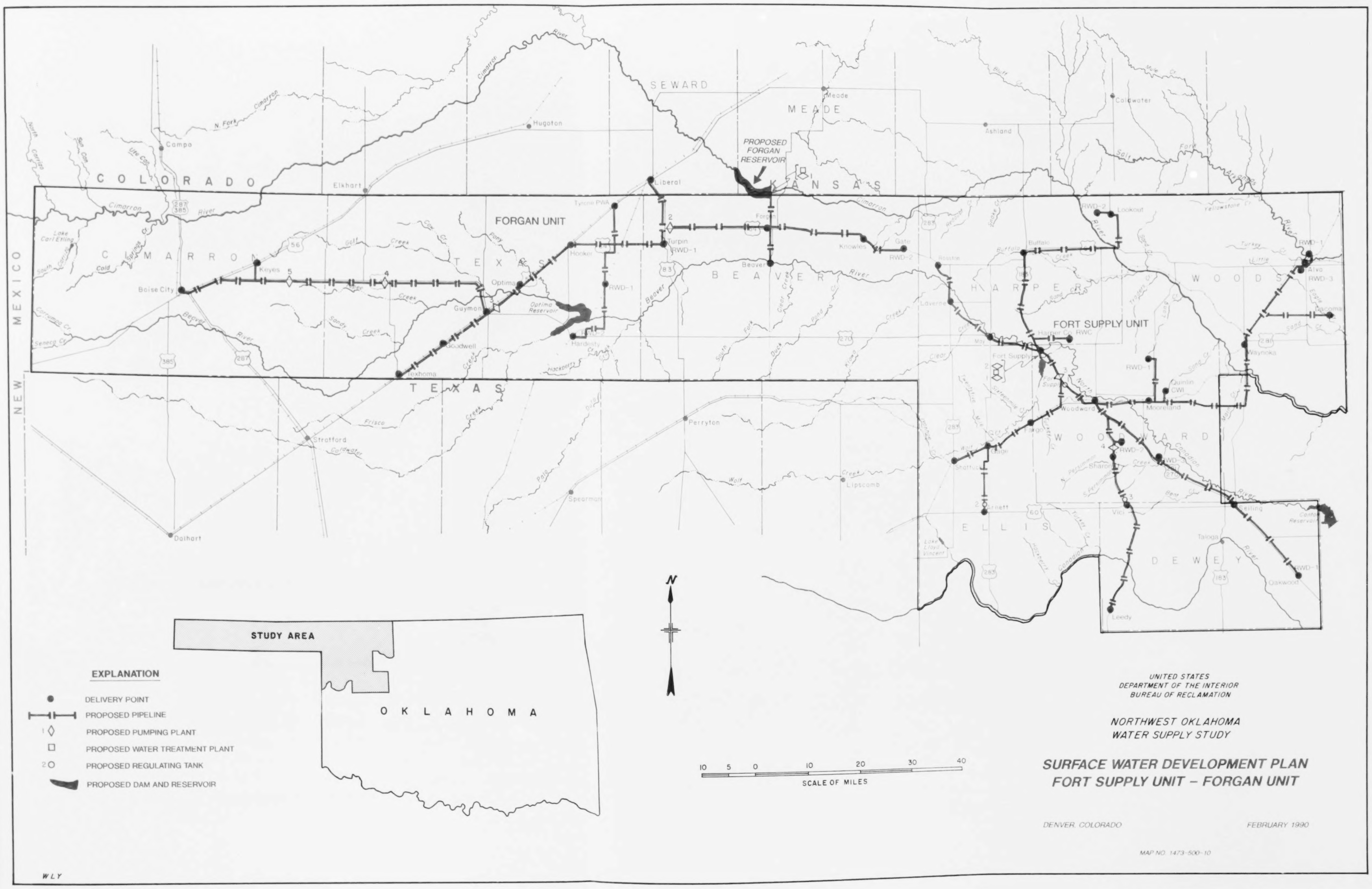
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

NORTHWEST OKLAHOMA
WATER SUPPLY STUDY

GENERAL MAP

DENVER, COLORADO JANUARY 1990

MAP NO. 1473-500-9



COLORADO
KANSAS
NEW MEXICO
TEXAS
OKLAHOMA
STUDY AREA
SEWARD
MEADE
CIMARRON
TEXAS
BEAVER
HARPER
WOODS
WOODWARD
ELLIS
DEWEY
FORGAN UNIT
FORT SUPPLY UNIT
PROPOSED FORGAN RESERVOIR
Optima Reservoir
Boise City
Keyes
Guymon
Optima
Goodwell
Texhoma
Hooker
Tyrone
Liberal
Turpin
Forgan
Beaver
Knowles
Gate
Hardesty
Elkhart
Hugoton
Campo
Meade
Ashland
Coldwater
Buffalo
Laverne
Fort Supply
Woodward
Mooreland
Waynoka
Alva
Freedom
Sharon
Vici
Seiling
Taloga
Oakwood
Leedy
Shattuck
Gage
Arnett
Lookout
Perryton
Stratford
Spearman
Lipscomb
Dalhart
RWD-1
RWD-2
RWD-3
Cimarron River
Beaver River
N
SCALE OF MILES
10 5 0 10 20 30 40
EXPLANATION
● DELIVERY POINT
PROPOSED PIPELINE
1 ◇ PROPOSED PUMPING PLANT
☐ PROPOSED WATER TREATMENT PLANT
2 ○ PROPOSED REGULATING TANK
PROPOSED DAM AND RESERVOIR
WLY

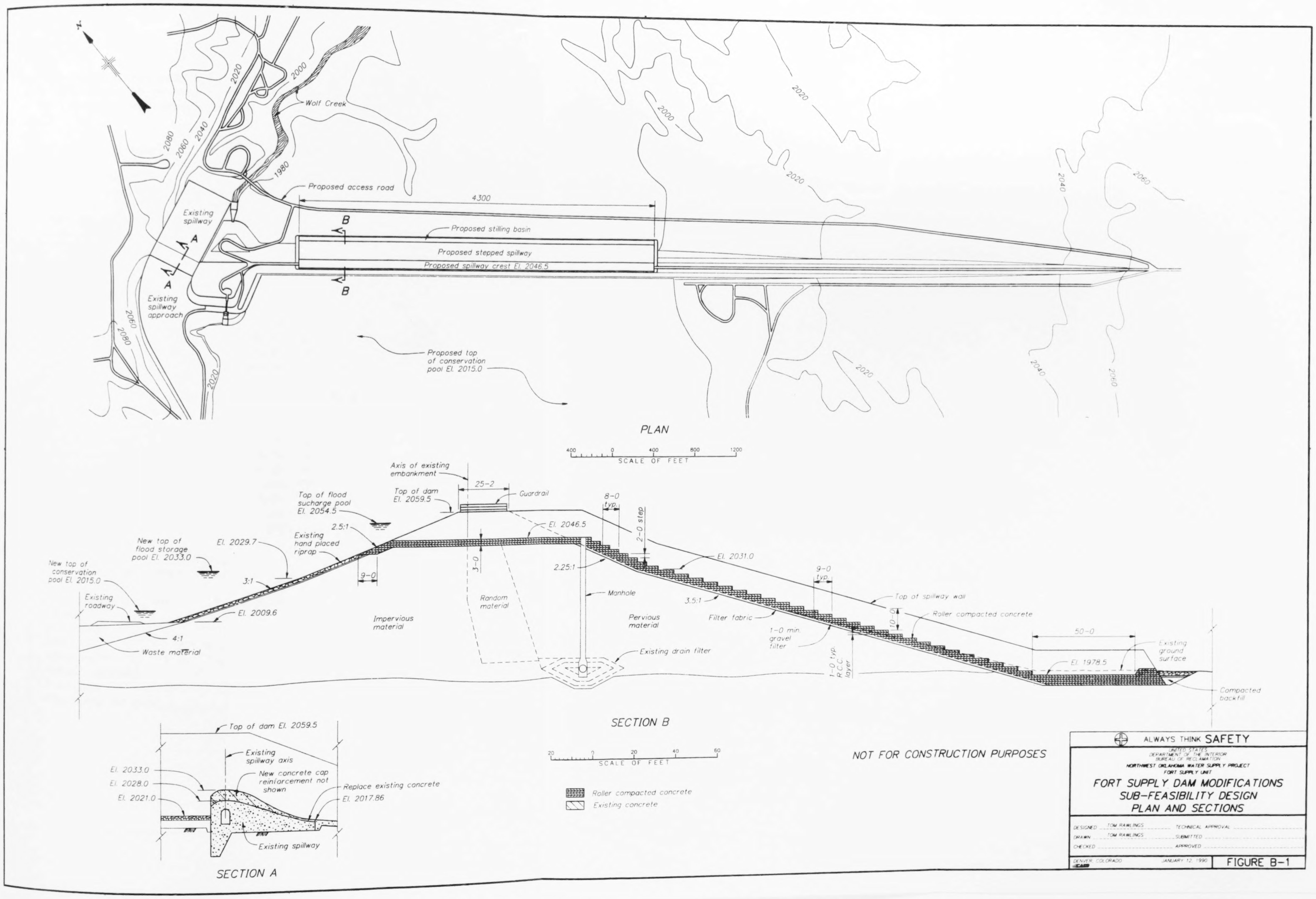
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

NORTHWEST OKLAHOMA
WATER SUPPLY STUDY

SURFACE WATER DEVELOPMENT PLAN
FORT SUPPLY UNIT – FORGAN UNIT

DENVER, COLORADO
FEBRUARY 1990

MAP NO. 1473-500-10


N
2080
2060
2040
2020
2000
1980
Wolf Creek
Proposed access road
4300
Existing spillway
A
A
B
B
Proposed stilling basin
Proposed stepped spillway
Proposed spillway crest El. 2046.5
Existing spillway approach
Proposed top of conservation pool El. 2015.0
PLAN
400 0 400 800 1200
SCALE OF FEET
Axis of existing embankment
25–2
Top of dam El. 2059.5
Guardrail
Top of flood sucharge pool El. 2054.5
8–0 typ.
2–0 step
2.5:1
El. 2046.5
New top of flood storage pool El. 2033.0
El. 2029.7
Existing hand placed riprap
3–0
El. 2031.0
2.25:1
New top of conservation pool El. 2015.0
3:1
9–0
9–0 typ.
Existing roadway
El. 2009.6
Random material
Manhole
3.5:1
Top of spillway wall
Impervious material
Pervious material
Filter fabric
10–0
Roller compacted concrete
4:1
1–0 min. gravel filter
50–0
Waste material
Existing drain filter
1–0 typ. R.C.C. layer
El. 1978.5
Existing ground surface
Compacted backfill
SECTION B
Top of dam El. 2059.5
Existing spillway axis
El. 2033.0
El. 2028.0
El. 2021.0
New concrete cap reinforcement not shown
Replace existing concrete
El. 2017.86
Existing spillway
SECTION A
20 0 20 40 60
SCALE OF FEET
Roller compacted concrete
Existing concrete

NOT FOR CONSTRUCTION PURPOSES

ALWAYS THINK SAFETY

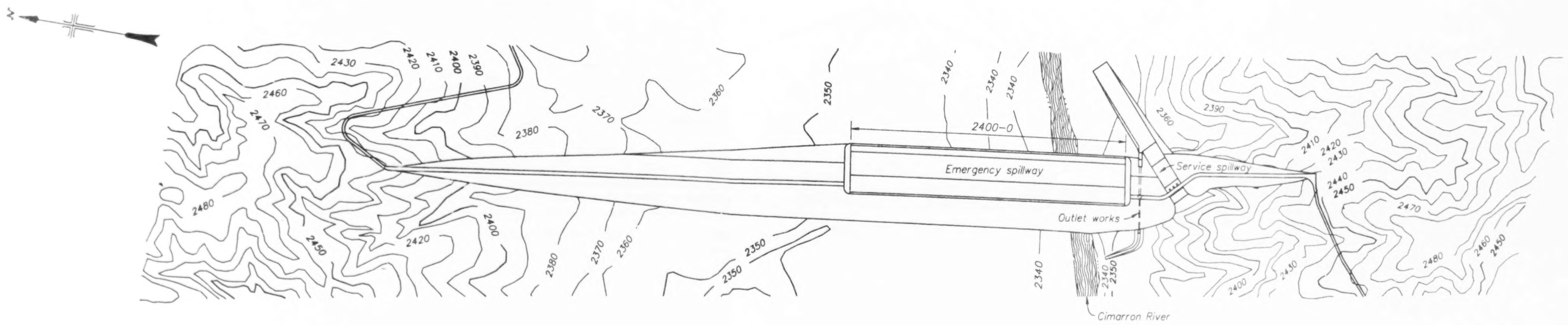
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NORTHWEST OKLAHOMA WATER SUPPLY PROJECT
FORT SUPPLY UNIT

FORT SUPPLY DAM MODIFICATIONS
SUB-FEASIBILITY DESIGN
PLAN AND SECTIONS

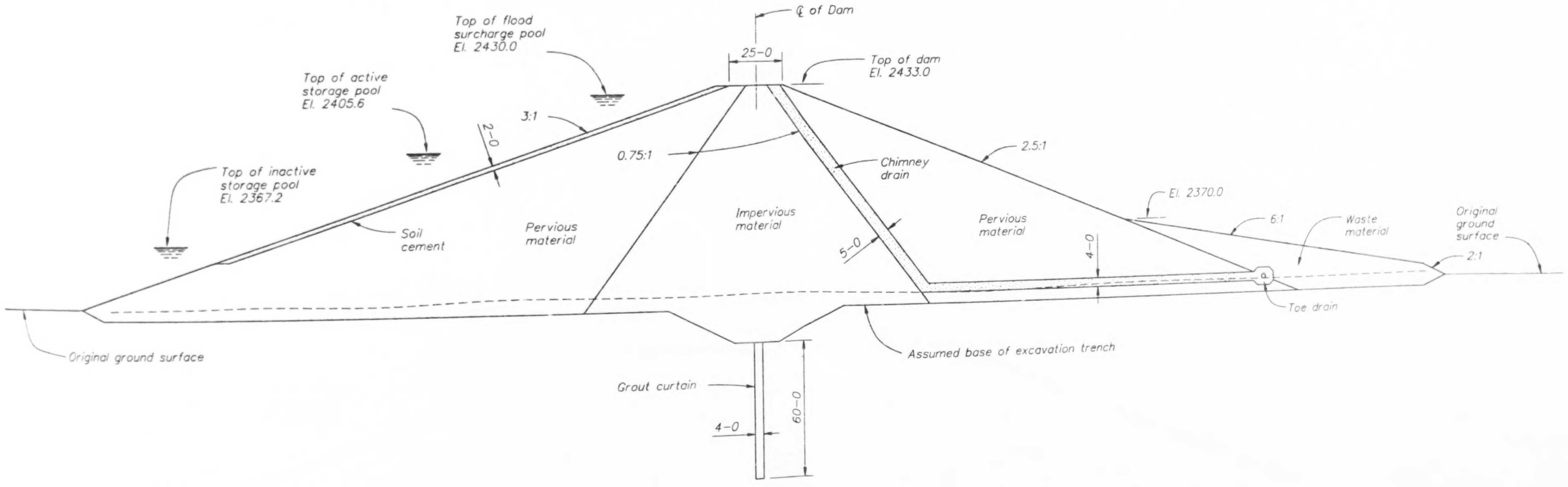
DESIGNED TOM RAWLINGS TECHNICAL APPROVAL
DRAWN TOM RAWLINGS SUBMITTED
CHECKED APPROVED

DENVER, COLORADO JANUARY 12, 1990

FIGURE B-1


N
2430
2420
2410
2400
2390
2460
2470
2480
2450
2380
2370
2360
2350
2340
2400-0
Emergency spillway
Service spillway
Outlet works
Cimarron River
400
0
400
800
1200
SCALE OF FEET

PLAN


℄ of Dam
25-0
Top of flood surcharge pool El. 2430.0
Top of dam El. 2433.0
Top of active storage pool El. 2405.6
3:1
2-0
0.75:1
Chimney drain
2.5:1
Top of inactive storage pool El. 2367.2
Soil cement
Pervious material
Impervious material
Pervious material
5-0
4-0
El. 2370.0
6:1
Waste material
Original ground surface
2:1
Toe drain
Original ground surface
Assumed base of excavation trench
Grout curtain
4-0
60-0
30
0
30
60
90
SCALE OF FEET

TYPICAL SECTION THROUGH DAM

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

JULY 6, 1990

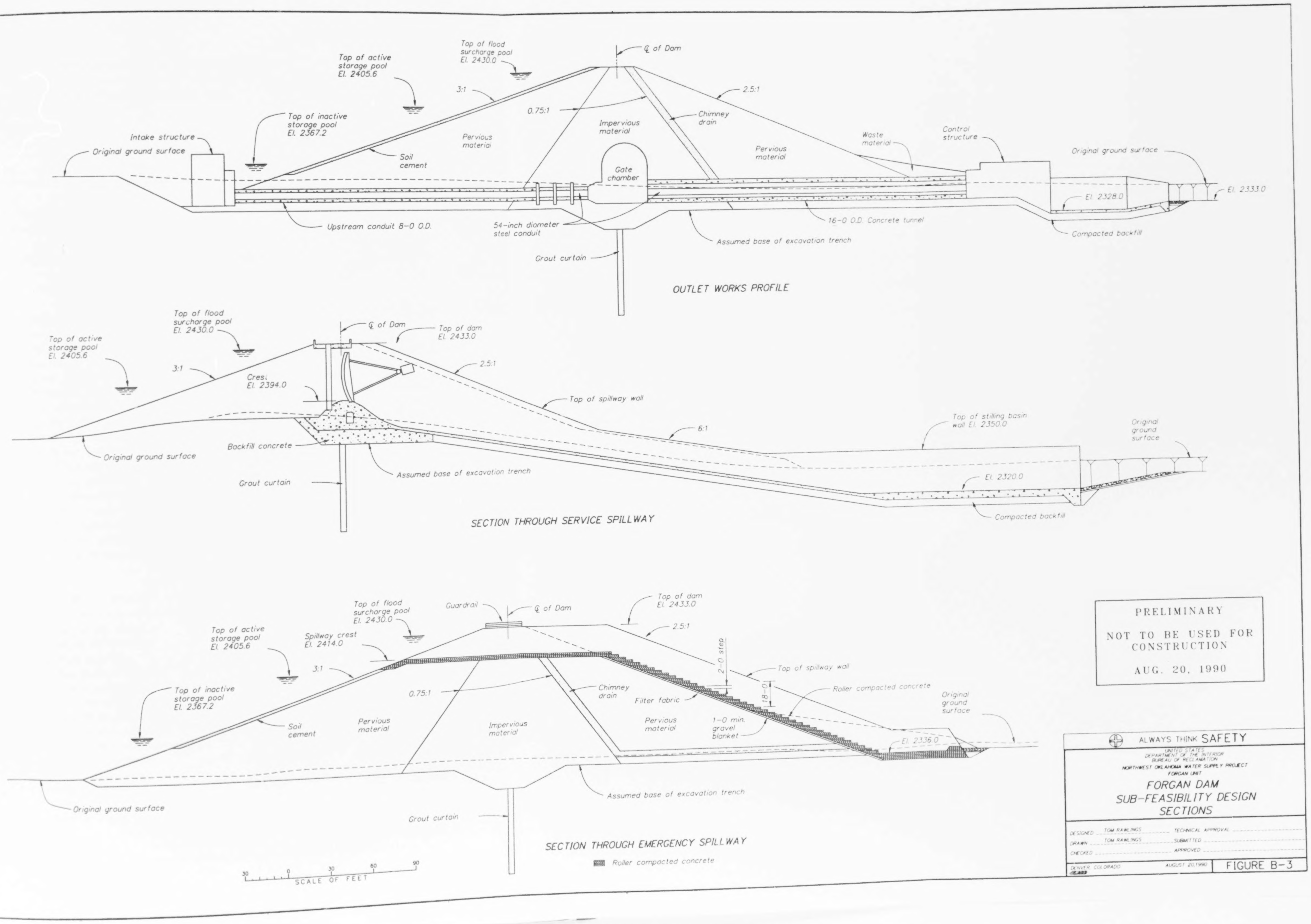
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NORTHWEST OKLAHOMA WATER SUPPLY PROJECT
FORGAN UNIT

FORGAN DAM
SUB-FEASIBILITY DESIGN
PLAN AND SECTION

DESIGNED TOM RAWLINGS TECHNICAL APPROVAL
DRAWN TOM RAWLINGS SUBMITTED
CHECKED APPROVED

DENVER, COLORADO JULY 6, 1990 FIGURE B-2


Top of flood surcharge pool El. 2430.0
℄ of Dam
Top of active storage pool El. 2405.6
3:1
0.75:1
2.5:1
Top of inactive storage pool El. 2367.2
Intake structure
Original ground surface
Soil cement
Pervious material
Impervious material
Chimney drain
Gate chamber
Pervious material
Waste material
Control structure
Original ground surface
El. 2333.0
El. 2328.0
Upstream conduit 8-0 O.D.
54-inch diameter steel conduit
16-0 O.D. Concrete tunnel
Assumed base of excavation trench
Compacted backfill
Grout curtain
Top of flood surcharge pool El. 2430.0
℄ of Dam
Top of dam El. 2433.0
Top of active storage pool El. 2405.6
3:1
2.5:1
Crest El. 2394.0
Top of spillway wall
6:1
Top of stilling basin wall El. 2350.0
Original ground surface
Original ground surface
Backfill concrete
Assumed base of excavation trench
Grout curtain
El. 2320.0
Compacted backfill
Top of flood surcharge pool El. 2430.0
Guardrail
℄ of Dam
Top of dam El. 2433.0
2.5:1
Top of active storage pool El. 2405.6
Spillway crest El. 2414.0
3:1
2-0 step
Top of spillway wall
1:8-0
Top of inactive storage pool El. 2367.2
0.75:1
Chimney drain
Filter fabric
Roller compacted concrete
Original ground surface
Soil cement
Pervious material
Impervious material
Pervious material
1-0 min. gravel blanket
El. 2336.0
Original ground surface
Assumed base of excavation trench
Grout curtain
▨ Roller compacted concrete
30 0 30 60 90
SCALE OF FEET

OUTLET WORKS PROFILE

SECTION THROUGH SERVICE SPILLWAY

SECTION THROUGH EMERGENCY SPILLWAY

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

AUG. 20, 1990

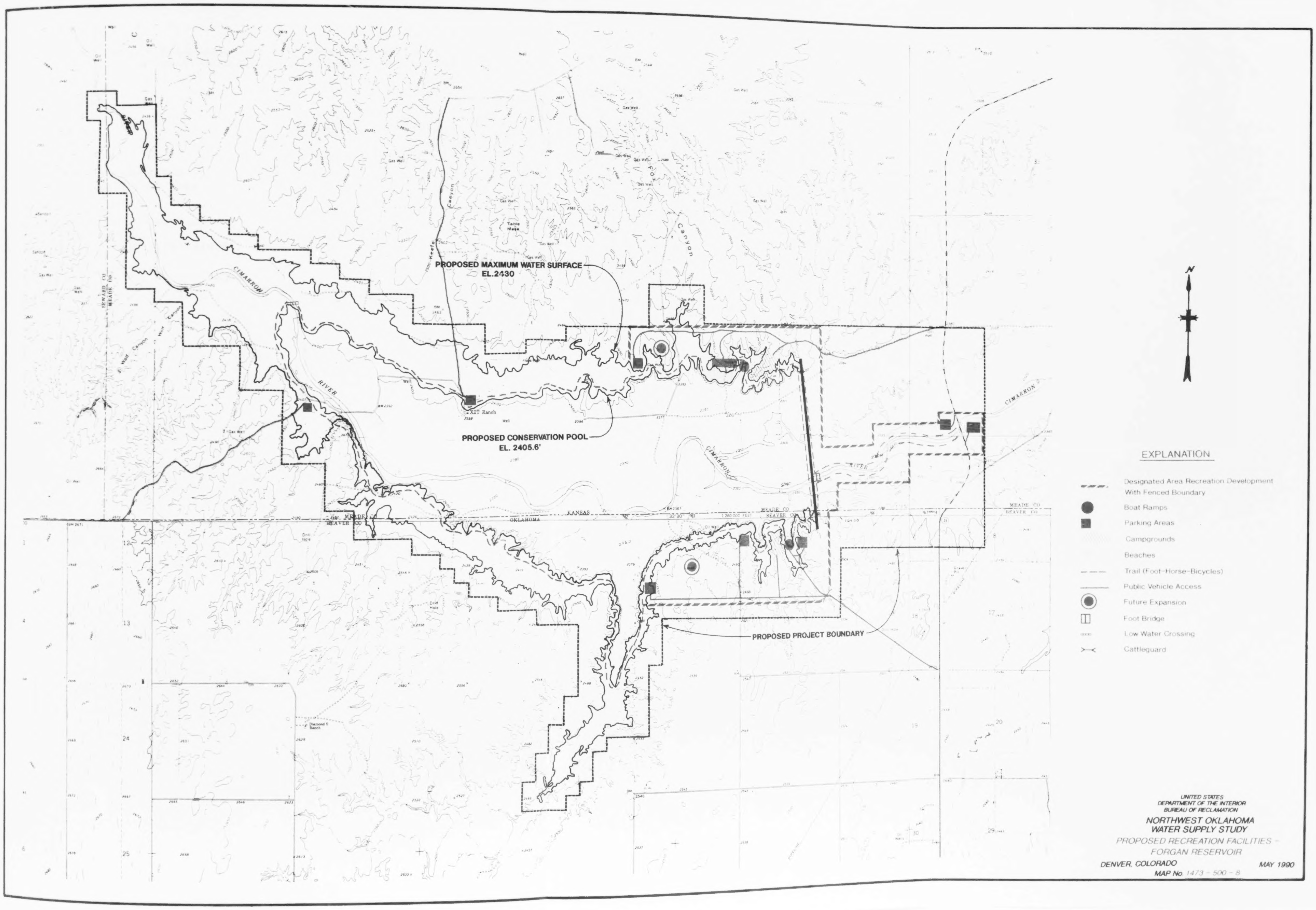
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NORTHWEST OKLAHOMA WATER SUPPLY PROJECT
FORGAN UNIT

FORGAN DAM
SUB-FEASIBILITY DESIGN
SECTIONS

DESIGNED TOM RAWLINGS
TECHNICAL APPROVAL
DRAWN TOM RAWLINGS
SUBMITTED
CHECKED
APPROVED
DENVER, COLORADO
AUGUST 20, 1990

FIGURE B-3


PROPOSED MAXIMUM WATER SURFACE
EL.2430
PROPOSED CONSERVATION POOL
EL. 2405.6'
PROPOSED PROJECT BOUNDARY
CIMARRON
RIVER
CIMARRON
RIVER
CIMARRON
XIT Ranch
Keefe Canyon
Canyon
Table Mesa
Gas Well
KANSAS
OKLAHOMA
MEADE CO.
BEAVER CO.
N
EXPLANATION
Designated Area Recreation Development With Fenced Boundary
Boat Ramps
Parking Areas
Campgrounds
Beaches
Trail (Foot-Horse-Bicycles)
Public Vehicle Access
Future Expansion
Foot Bridge
Low Water Crossing
Cattleguard

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

**NORTHWEST OKLAHOMA
WATER SUPPLY STUDY**

*PROPOSED RECREATION FACILITIES –
FORGAN RESERVOIR*

DENVER, COLORADO MAY 1990
MAP No. 1473 – 500 – 8